

# SDMS US EPA REGION V

## FORMAT- OVERSIZED - 5

### IMAGERY INSERT FORM

The item(s) listed below are not available in SDMS. In order to view original document or document pages, contact the Superfund Records Center.

<b>SITE NAME</b>	<b>SAUGET AREA 1</b>		
<b>DOC ID #</b>	<b>154079</b>		
<b>DESCRIPTION OF ITEM(S)</b>	<b>SITE LOCATION MAPS (BLUE PRINTS)</b>		
<b>REASON WHY UNSCANNABLE</b>	<u>  X  </u> <b>OVERSIZED</b>	<b>OR</b>	<u>      </u> <b>FORMAT</b>
<b>DATE OF ITEM(S)</b>			
<b>NO. OF ITEMS</b>	<b>MULTIPLE</b>		
<b>PHASE</b>	<b>REM</b>		
<b>PRP</b>			
<b>PHASE (AR DOCUMENTS ONLY)</b>	<u>      </u> <b>Remedial</b> <u>      </u> <b>Removal</b> <u>      </u> <b>Deletion Docket</b> <u>      </u> <b>AR</b> <u>      </u> <b>Original</b> <u>      </u> <b>Update #</b> <u>      </u> <b>Volume</b> <u>      </u> <b>of</b> <u>      </u>		
<b>O.U.</b>			
<b>COMMENT(S)</b>			
FIGURES 1-2; 8-14; 23-25			

Geraghty & Miller, Inc.

154079 K.03  
9/1/86

**PLANT-WIDE ASSESSMENT OF  
GROUND-WATER CONDITIONS  
AT THE W.G. KRUMRICH PLANT  
MONSANTO COMPANY  
SAUGET, ILLINOIS  
VOLUME I - DATA ANALYSIS**

September 1986

Prepared by:

Geraghty & Miller, Inc.  
Ground-Water Consultants  
125 East Bethpage Road  
Plainville, New York 11803

CONTENTS

VOLUME I - DATA ANALYSIS

	<u>Page</u>
INTRODUCTION.....	1
GEOLOGY.....	3
GROUND-WATER MOVEMENT.....	6
Historical Ground-Water Flow Patterns.....	6
Current Ground-Water Flow Patterns.....	8
August 1984.....	9
November 1985.....	12
Hydrograph Records.....	14
AQUIFER TESTS.....	17
Water-Table Zone.....	17
Intermediate Zone.....	18
Deep Zone.....	20
GROUND-WATER VELOCITY.....	21
Water-Table Zone.....	21
Intermediate Zone.....	22
Deep Zone.....	22
GROUND-WATER QUALITY.....	24

TABLES

1. Well Inventory of Off-Site Wells Located in the East St. Louis - Sauget - Cahokia Area, Illinois
2. Static Water Levels for Monitoring Wells Measured During August 24 - 27, 1984
3. Static Water Levels for Monitoring Wells Measured During November 21 - 22, 1985
4. Summary of Construction Details for Monitoring Wells Installed Under the Direction of Geraghty & Miller, Inc.
5. Summary of Construction Details for Monitoring Wells Installed under the Direction of D'Appolonia Waste Management Services, Inc.
6. Summary of Construction Details for Monitoring Wells Installed under the Direction of Law Engineering Testing Company
7. Water-Level Measurements for Determining Aquifer Characteristics Based on Slug Tests Performed on Wells GM-1, GM-2 and GM-3

TABLES (Continued)

8. Summary of Slug Test Results For Selected Water-Table Zone Wells
9. Laboratory and Field Permeability Test Results Performed by D'Appolonia Waste Management Services, Inc.
10. Aquifer Characteristics Based on Aquifer Tests in Madison and St. Clair Counties, Illinois
11. Summary of Water-Quality Analyses for USEPA Priority Pollutant and Non-Priority Pollutant Organic Compounds
12. Summary of Volatile Organic Compounds in Ground Water in Well GM-12A
13. Mean Concentrations of Volatile Organic Compounds in Field, Trip and Laboratory Blanks
14. Analysis of Precision and Error Among Replicates from Well GM-12A

FIGURES

1. Area Wells Inventoried Prior to the Study
2. Location Map and Line of Geologic Cross-Section
3. Geologic Cross Section
4. Estimated Pumpage in the East St. Louis - Sauget - Cahokia Area 1890 - 1980
5. Approximate Elevation of the Potentiometric Surface, November 1961
6. Approximate Elevation of the Potentiometric Surface, June 1973
7. Approximate Elevation of the Potentiometric Surface, November 1980
8. Configuration of the Water Table, August 1984
9. Potentiometric Surface of the Intermediate Zone, August 1984
10. Potentiometric Surface of the Deep Zone, August 1984
11. Configuration of the Water Table, November 1985
12. Potentiometric Surface of the Intermediate Zone, November 1985
13. Potentiometric Surface of the Deep Zone, November 1985
14. Potentiometric Surface of the Rock Aquifer, November 1985
15. Hydrographs for GM-1 and the Mississippi River and Precipitation Data
16. Hydrographs for GM-2 and the Mississippi River and Precipitation Data
17. Hydrographs for GM-3 and the Mississippi River and Precipitation Data
18. Hydrographs for GM-9B and the Mississippi River and Precipitation Data
19. Hydrographs for GM-27B and the Mississippi River and Precipitation Data
20. Hydrographs for GM-9C and the Mississippi River and Precipitation Data

FIGURES (Continued)

21. Hydrographs for GM-27C and the Mississippi River and Precipitation Data
22. Hydrographs for GM-106 and the Mississippi River and Precipitation Data
23. Mean Concentrations of Priority Pollutant and Non-Priority Pollutant Compounds in the Water-Table Zone
24. Mean Concentrations of Priority Pollutant and Non-Priority Pollutant Compounds in the Intermediate Zone
25. Mean Concentrations of Priority Pollutant and Non-Priority Pollutant Compounds in the Deep Zone

VOLUME II - CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS.....	1
Offsite Impacts.....	1
Sources.....	4
RECOMMENDATIONS.....	7
Remedial Action.....	7
Ground-Water Monitoring.....	11
REFERENCES.....	13

TABLES

15. Estimates of Loading to the Mississippi River
16. Dilution Effects in the Mississippi River
17. Pollutant Loadings, Mississippi River-West Section, Dry Weather Event, April 15, 1982
18. Frequency of Pollutant Occurrence, Mississippi River Water, Downstream-Center and East Sections (11/24/81, 11/30/81, 4/15/82)
19. Semi-Annual Ground-Water Monitoring Program, Monsanto Company, W.G. Krummrich Plant, Sauget, Illinois

FIGURES

26. Approximate Areas Where Organic Compound Concentrations are above 100 ug/L in the Shallow Zone on the Monsanto Property
27. Approximate Areas Where Organic Compound Concentrations are above 100 ug/L in the Intermediate Zone on the Monsanto Property

VOLUME III - APPENDICES

APPENDIX

- A. Geraghty & Miller, Inc. Drilling and Sampling Protocols
- B. Geologic Logs
- C. Well Construction Data
- D. Summary of John Mathes & Associates, Inc.  
Laboratory Permeability Test Results

E. Water Quality Data

- Table E-1. Summary of Volatile Organic Compounds in  
Ground Water
- Table E-2. Summary of Acid Extractable Organic  
Compounds in Ground Water
- Table E-3. Summary of Base/Neutral Extractable Organic  
Compounds in Ground Water
- Table E-4. Summary of Pesticide/PCB Compounds in Ground  
Water
- Table E-5. Summary of Metals and Miscellaneous  
Parameters in Ground Water

PLANT-WIDE ASSESSMENT OF  
GROUND-WATER CONDITIONS  
AT THE W.G. KRUMMRICH PLANT,  
MONSANTO COMPANY,  
SAUGET, ILLINOIS

INTRODUCTION

Geraghty & Miller, Inc. was retained by the Monsanto Company to investigate ground-water conditions at the W.G. Krummrich Plant in Sauget, Illinois. The purpose of the study was to determine the direction and rate of ground-water flow and to characterize ground-water quality.

The field program began in October 1983 with the installation and sampling of 12 shallow wells. Since that time, additional phases of work have included a soil boring investigation, the installation of cluster monitoring wells, the determination of aquifer characteristics, and the collection of water-level and water-quality data from monitoring wells and wells associated with dewatering projects. These programs were designed to describe ground-water flow patterns, inter-aquifer flow, and the distribution of dissolved chemicals in the ground water.

This report describes the geology and hydrogeology of the study area. Ground-water velocities have been calculated and ground-water flow patterns have been mapped. The distributions of Priority Pollutant chemicals (and other

compounds) have been illustrated to show their occurrence in the study area.

Volume I contains an analysis of most of the data and a summary of water quality information. Conclusions and recommendations are presented in Volume II. The appendices (Volume III) contain basic water-quality data and a description of the protocols employed during drilling and sampling. A detailed description of the field program is provided in Appendix A. Geologic logs and well construction diagrams are included in Appendices B and C, respectively. The results of vertical permeability measurements performed on soil samples from the cap of the Monsanto Landfill are included in Appendix D. Water quality data appear in Appendix E.



### GEOLOGY

The W.G. Krummrich Plant is situated on the flood plain of the Mississippi River, south of East St. Louis, at Sauget, Illinois. Figure 1 shows the Monsanto property with respect to local landmarks. The flood plain is locally named the American Bottoms, and contains unconsolidated valley fill deposits composed of recent alluvium (Cahokia Alluvium) which overlies glacial material (Henry Formation). Published information indicates that these unconsolidated deposits are underlain by bedrock of Mississippian age which consists of limestone and dolomite with lesser amounts of sandstone and shale.

The Cahokia Alluvium (recent deposits) consists of unconsolidated, poorly sorted, fine-grained materials with some local sand and clay lenses. The material is about 40 feet thick and becomes coarser with depth. These recent alluvium deposits unconformably overlie the Henry Formation which is Wisconsinan glacial outwash in the form of valley-train deposits. The Henry Formation is about 95 feet thick at the Mississippi River and becomes thinner with increasing distance from the river. These valley-train materials are generally medium to coarse sand and gravel and also increase in grain size with depth. In some areas, till and/or boulder zones were encountered 10 to 15 feet above the bedrock.

During the various drilling programs conducted on-site, the alluvium was determined to consist of fine gray and brown silty sand up to 40 feet below land surface. A cross-section of the study area is provided for the line of section shown on Figure 2 and presented in Figure 3. The geologic data show that the unconsolidated deposits range from 140 feet thick near the river to about 110 feet in the eastern part of the Monsanto property. The geologic logs for the drilling programs conducted by Geraghty & Miller, Inc. are provided in Appendix B.

A review of well and boring logs for several drilling programs conducted by D'Appolonia Waste Management Services, Inc. (currently IT Corporation) and Law Engineering at the W.G. Krummrich Landfill indicates that directly beneath the fill are discontinuous lenses of silty/sandy clays interbedded with silty sands which range in thickness from 20 to 50 feet. The nature of this material was so variable from boring to boring that D'Appolonia believed the continuity of the silty clay was less likely than the continuity of the more permeable silty sand. This semi-confining unit overlies coarser, more permeable sand and gravel.

During the drilling program it was not possible to distinguish the contact or boundary between the Cahokia Alluvium and the Henry Formation, and for evaluating the hydrogeology of the area, it is not necessary to do so.

Aquifer properties such as transmissivity are more important than geological distinctions. Therefore, for the hydrogeologic assessment, the unconsolidated material above the bedrock was divided into 3 zones according to relative transmissivities. A fine-grained low transmissivity zone is present from the water table to about 40 feet below the surface, a more permeable intermediate zone exists between 40 and 90 feet, and a deep zone which contains the most permeable material lies between 90 feet and bedrock (approximately 130 feet).

## GROUND-WATER MOVEMENT

### Historical Ground-Water Flow Patterns

Ground water in the Henry Formation occurs under leaky artesian and water-table conditions. Recharge in this area occurs from (1) precipitation, (2) induced infiltration of surface water from the Mississippi River and small streams as a result of ground-water pumping, and (3) underflow from the east. Recharge by induced infiltration occurs where pumping large quantities of ground water has lowered the water table below the water level in the Mississippi River and nearby streams.

In the past, large supplies of ground water were withdrawn from permeable sand and gravel of the valley fill (Henry Formation) in the East St. Louis-Sauget-Cahokia area. The coarsest deposits (and most favorable for pumping large volumes of ground water) are located near bedrock. Most, if not all, of the wells are screened in these deposits (Ritchey, et al., 1984).

Ground-water pumpage in the Monsanto area was largely from industrial wells. Figure 4 illustrates the estimated pumpage in the East St. Louis-Sauget-Cahokia area from 1890 to 1980. Pumpage increased up to 1962 as demands required greater withdrawals. As a result of increased ground-water

conservation at one industry (1962-1965), the closing of two major ground-water-using industries (1970-1971), and the conversion to the use of the Mississippi River as a source of water (1972-1977), ground-water withdrawals decreased from 35.5 million gallons per day (mgd) in 1962 to 0.5 mgd in 1980 (Ritchey, et.al, 1984). A regional deterioration in water quality was probably the primary reason for changing from ground water to surface water.

The changes in ground-water withdrawals from 1961 to 1980, and the resultant effect on the potentiometric surface in the Henry Formation, have been illustrated in a series of figures (Figures 5 to 7). Figure 5, (based on 1961 data), clearly depicts locations of pumping centers and their associated cones of depression. Monsanto's supply wells (in the plant area) appear to be at the center of the largest cone of depression, and they drew ground water from all directions. Therefore, ground-water flow was toward the Monsanto property from adjacent properties, which include AMAX, Cerro and Mid-West Rubber. A smaller and deeper cone of depression, due to the pumping of Monsanto's Ranney Well No. 3, is evident about one mile west of the main pumping center, adjacent to the Mississippi River.

Ground-water levels in June 1973 (Figure 6) were at record high elevations, due primarily to a prolonged period of high river stage and extensive flooding in 1973. It is

also important to note that ground water beneath the W.G. Krummrich Landfill, was being drawn away from the Mississippi River toward the plant process-area production wells. In addition, ground-water on adjacent properties was still traveling toward the Monsanto wells.

In November 1980 (Figure 7), ground-water flow was toward the Mississippi River for the first time since the pre-pumping period. The re-establishment of natural flow conditions in the early 1980's represents a major ground-water flow reversal which resulted from the cessation of large ground-water withdrawals.

#### Current Ground-Water Flow Patterns

In order to assess current flow patterns, Geraghty & Miller, Inc. inventoried existing wells within an approximate 2-mile radius from the Monsanto property. These wells are shown on Figure 1, and available well construction details are provided in Table 1. Any supply well that could potentially influence ground-water flow patterns on the site was mapped. Well information was obtained from files of the Illinois Geological Survey, the Illinois State Water Survey and U.S. Geological Survey. Figure 4 shows the dramatic decrease in ground-water use from 1962 to 1980 for the East St. Louis - Sauget - Cahokia area. At the present time, ground water is not used for potable supplies. The

small ground-water withdrawals are limited to industrial use.

The current ground-water flow patterns have been illustrated for the three hydrogeologic zones and for a small portion of the bedrock aquifer adjacent to the Mississippi River. The configuration of the water table and the potentiometric surface for the intermediate and deep zones have been drawn for August 1984 and November 1985 to illustrate what effect rising and falling levels in the Mississippi River have on ground-water flow patterns during periods of high and low river stage.

Water-level measurements were made in all available wells between August 24 and 27, 1984 and again on November 21 and 22, 1985 (Tables 2 and 3). The construction details for these wells are provided in Tables 4, 5 and 6. Figures 8 through 10 depict water level elevations in August 1984 and Figures 11 through 14 illustrate the configuration of the water-table and potentiometric surfaces in November 1985.

- August 1984 -

The configuration of the water table in August 1984 (Figure 8) demonstrates that ground-water flow in the uppermost saturated unit (water-table zone) is toward the Mis-

Mississippi River. At that time, the Mississippi River stage was 5 to 7 feet above the U.S. Corps of Engineers datum at the Market Street station in St. Louis.

A ground-water mound exists beneath a portion of the plant area. The mound appears to be caused by a combination of hydrogeologic factors and leaks in a water line, sewer and roof drains all of which were subsequently repaired. The eastern part of the property has a surficial layer of silt and/or clay. The lower permeability of these deposits compared to the surrounding area probably causes the ground-water head to build up. The leaky water line increased the head, which has declined since the line was repaired.

A ground-water mound also exists beneath the W.G. Krummrich landfill. The elevated water levels are probably the result of a combination of several hydrogeologic factors. Fine silty sand deposits, and lenses of silt and clay, exist beneath the landfill. The low permeability of these fine-grained materials and the waste materials tends to cause local perched water-table conditions, particularly when a high river stage results in a great deal of bank storage. The August 1984 water-level round was conducted approximately 50 days after flood stage which does not appear to be enough time for drainage to cause the mound to disappear.



In addition, a portion of the landfill adjacent to the Monsanto Landfill is located along the Krummrich landfill's eastern border, where runoff tends to accumulate. This property is devoid of vegetation, as is covered with sand, gravel and fly ash. This type of surface will permit a great deal of infiltration because of the relatively high permeability of these materials compared to the surrounding areas. This increased infiltration probably maintains the mound under the landfills.

It is unlikely that leakage through the cap on the Monsanto Landfill is responsible for the mound. John Mathes & Associates, Inc. (Columbia, Illinois) performed two sets of vertical permeability tests on soil collected from the upper two feet of the cap material in December 1985. Vertical permeability values ranged from  $3.9 \times 10^{-7}$  to  $2.4 \times 10^{-6}$  cm/sec (centimeters per second). These values are very low compared to the permeability of the material on the adjacent property which probably permits a much larger percentage of precipitation to enter the ground-water system. This localized upgradient recharge area probably contributes significantly to the elevated water-levels observed in the shallow wells in the Monsanto landfill and its immediate vicinity. Appendix D contains the Mathes report of the vertical permeability tests.

Finally, dewatering for the sewer project (north of the landfill) may be partially responsible for the mound. The water-table depression located near the northeast corner of the landfill is the result of several pumping dewatering wells in the intermediate zone. The 10-foot head difference between the water table and intermediate zones appears to have exaggerated the true head difference because of pumping.

The potentiometric surface of the intermediate zone (40 to 90 feet below land surface) in August 1984 is depicted on Figure 9. Ground-water flow in this portion of the unconsolidated deposits is toward the Mississippi River. Flow is being diverted in the area north of the landfill due to dewatering activities.

The potentiometric surface of the deep zone (90 to approximately 130 feet below land surface) in August 1984 is illustrated on Figure 10. The elevation of the water levels and the ground-water flow patterns are similar to those of the intermediate zone.

- November 1985 -

In contrast to low river stage (5 to 7 feet) in August 1984, the Mississippi River was 32 to 33 feet above the U.S. Army Corps of Engineers datum in November 1985. The effect

of high river stage on the ground-water system is clearly demonstrated in Figures 11 through 14.

The configuration of the water table in November 1985 (Figure 11) shows that the high river stage has caused a reversal in ground-water flow when compared to August 1984. Ground-water movement is away from the Mississippi River in response to a gradient which extends eastward to a ground-water divide located 3,500 feet from the river. A ground-water mound still exists under a portion of the plant area. Dewatering operations near the river were temporarily suspended due to the river level at the time of the water-level measurements.

The potentiometric surface of the intermediate zone for November 1985 is shown on Figure 12. Ground-water flow in this zone is also easterly away from the river, for a distance of approximately 4,500 feet. A cone of depression is evident in the plant area, as a result of a dewatering project.

The potentiometric surface of the deep zone for November 1985 is shown on Figure 13. The elevation of the water levels and the direction of ground-water flow are similar to those of the intermediate zone.

The water-level elevations for a small portion of the bedrock aquifer in November 1985 are depicted in Figure 14. Ground-water flow is also in an easterly direction.

- Hydrograph Records -

In November 1983, continuous Steven's water-level recorders, equipped with monthly clocks, were installed on Wells GM-1, GM-2 and GM-3, which tap the water-table zone. Wells GM-9B and GM-27B (intermediate zone) and Wells GM-9C and GM-27C (deep zone) were equipped with water-level recorders in September 1984, after their completion. The continuous water-level record for the bedrock aquifer began in November 1985 (Well GM-106). These water-level data are illustrated on Figures 15 through 22, with precipitation and Mississippi River records included for comparison.

The hydrographs provide ground-water levels over time for each of the three hydrogeologic zones, as well as for the bedrock aquifer. Precipitation records are from Lambert - St. Louis International Airport. The river stage data were measured by the U.S. Army Corps of Engineers at the Market Street station in St. Louis.

The hydrographs for the water-table wells (GM-1, GM-2, and GM-3) are similar because each well monitors the shallow zone (Figures 15 through 17). Changes in the water-table

elevation in the areas that were monitored correlate better with variations in precipitation and pumpage, rather than with river stage fluctuations. However, during flood stage, the water-level in well GM-3 can be influenced by the river level, as shown in the ground-water flow map for November 1985 (Figure 11).

Superimposed on the precipitation-dependent changes in the water level on each hydrograph is a "sawtooth" pattern which is regular and indicative of a response to pumpage, possibly on an adjacent property. In addition to the pumpage from nearby well(s), dewatering operations on adjacent properties are also likely to have had an effect.

The potentiometric surface in the intermediate zone has been continuously monitored in wells GM-9B (plant area) and GM-27B (landfill area) since September 1984 (Figures 18 and 19). Water levels in Well GM-27B respond quickly to change in river stage because the well is located adjacent to the river. In addition, its response to dewatering operations along the north side of the landfill is also quite evident. Changes due to precipitation are obscured by river stage fluctuations and local pumpage.

Figure 18 shows that the water level in well GM-9B is affected less by river stage than other wells closer to the River. However, the response of the potentiometric surface

to precipitation is also obscured due to continuous dewatering conducted in this area since 1983.

The potentiometric surface in the deep zone has also been continuously monitored since September 1984 (Figures 20 and 21). The deep zone is monitored at the same locations as the intermediate zone, in wells GM-9C and GM-27C. The changes in water levels in the deep zone are similar to those in the intermediate zone because river stage and dewatering operations have the same impact on ground-water flow direction, although the magnitude of the changes are less.

The continuous water-level record for the rock aquifer began in November 1985 after completion of a large diameter (8-inch) bedrock well (Figure 22). The hydrograph for this well is very similar to river stage fluctuations for the period of record.

AQUIFER TESTSWater-Table Zone

In November 1983, slug tests were conducted by Geraghty & Miller, Inc. in Wells GM-1, GM-2 and GM-3 (6-inch diameter). The purpose of these tests was to determine aquifer transmissivity, hydraulic conductivity (permeability) and the storage coefficient in the uppermost saturated unit.

A weight of a known volume was lowered below the water level in each well, displacing the water column upward. Measurements of the water-level decline were made with an electric probe at 15-second intervals. The test began as soon as the weight was lowered below the water level in the well, and the test ended when the water level in the well had declined to the original pre-test static level. Water-level measurements and elapsed times are given in Table 7.

The method used to analyze the slug test data was developed by Cooper, Bredehoeft, and Papadopoulos (Lohman, 1972). The technique is applicable to wells screened across the entire thickness of a confined aquifer of rather low transmissivity. If the tested well is screened across part of the aquifer, the transmissivity values only apply to that part of the aquifer in which the well is screened or open.

Table 8 summarizes data for Wells GM-1, GM-2, and GM-3. The calculated hydraulic conductivities of the water-table zone ranged from 1.9 to 23 gallons per day per square foot ( $\text{gpd}/\text{ft}^2$ ) and averaged  $9.5 \text{ gpd}/\text{ft}^2$ . The calculated transmissivity values ranged from 28.5 to 344.3  $\text{gpd}/\text{ft}$  and averaged 141.5  $\text{gpd}/\text{ft}$ . These values may be somewhat higher than the actual transmissivities because of the effect of the gravel pack around portions of the well screens.

In the landfill area adjacent to the Mississippi River, D'Appolonia Waste Management Services, Inc. obtained several Shelby tube samples of the fine grained material underlying the fill for the purpose of determining the permeability. In addition, field permeability tests were conducted in several of the borings by D'Appolonia during its investigation. These data are provided in Table 9 and indicate that the permeability of the fine grained material is extremely variable with a range of 0.004 to  $8.7 \text{ gpd}/\text{ft}^2$  based on laboratory analyses, and a range of 3.8 to  $127.2 \text{ gpd}/\text{ft}^2$  as reported from the field testing program.

#### Intermediate Zone

Schicht (1965) provided aquifer test data for six sites in Madison and St. Clair Counties (Table 10). Three of these tests were performed on wells which most likely tap the intermediate zone (Olin Mathieson Chemical Corporation,



City of Wood River, and Southwestern Campus of Illinois University, Edwardsville). Mean transmissivity and permeability values were determined to be 120,200 gpd/ft and 1,620 gpd/ft<sup>2</sup>, respectively. The storage coefficients were representative of water-table conditions, as they ranged from 0.020 to 0.155.

John Mathes & Associates, Inc. conducted an aquifer test in September 1983 in the intermediate zone on Monsanto property. The purpose of the test was to determine well size, well spacing and discharge rates that would be required to complete the new main south trunk sewer in the plant area.

The aquifer test was carried out in an existing 18-inch diameter well, 65 feet deep, located adjacent to the ACL Building (near Well DW-5) in the plant area. The well was pumped for 48 hours at a rate which varied during the early portion of the test, but stabilized at 715 gpm during the last 24 hours of the testing period. Nine observation wells were monitored during the test.

Geraghty & Miller, Inc. evaluated the aquifer test data and determined the following aquifer characteristics of the intermediate zone: Transmissivity = 165,000 gpd/ft, hydraulic conductivity (permeability) = 3,300 gpd/ft<sup>2</sup>, and storage coefficient = 0.04.

### Deep Zone

Table 10 also provides hydrogeological characteristics of the deep zone specifically, transmissivity, permeability, and storage coefficient values, for sites at Shell Oil Company, Mobil Oil Company and Monsanto. The aquifer test performed in 1952 on a Monsanto test well was located near Ranney Well No. 3. The saturated thickness of the aquifer, at the time of the aquifer tests, varied from 73 feet on Mobil's property to about 100 feet at Shell Oil Company, about three miles to the northeast. Mean transmissivity and permeability values were calculated to be 211,000 gpd/ft and 2,600 gpd/ft<sup>2</sup>, respectively. The coefficient of storage represents water-table conditions for the Mobil site (0.100) and at Monsanto (0.082); however, a value of 0.002, indicative of artesian conditions occurs at the Shell Oil Company site.

GROUND-WATER VELOCITYWater-Table Zone

Ground-water velocity in the water-table zone was determined using the following form of Darcy's Law:

$$V = \frac{KI}{xn}$$

where:

- V = velocity, in feet per day
- K = hydraulic conductivity of the deposits in the direction of flow, in gallons per day per square foot
- I = hydraulic gradient, in feet per foot
- n = effective porosity, which is dimensionless (Walton, 1984)
- x = 7.48 gallons per cubic feet

To compute the velocity value, the following data were used: the average hydraulic conductivity value obtained during Geraghty & Miller, Inc.'s aquifer testing of the shallow zone (9.5 gpd/ft<sup>2</sup>); the hydraulic gradient (0.0025) which was measured in an area on the August 1984 water-table map (Figure 8) unaffected by either mounding or pumping conditions; and an assumed effective porosity of 15 percent which was estimated from the range (10-30) given for fine sand by Walton (1984). Because the water table zone consists of silty sand, a value at the low end of the range was chosen. The calculated velocity is 0.02 feet per day (7.3 feet per year) for the upper 15 feet of the saturated zone.

### Intermediate Zone

Ground-water velocity in the intermediate zone of the Henry Formation was also calculated using Darcy's Law. The hydraulic conductivity ( $3,300 \text{ gpd/ft}^2$ ) was obtained by dividing the transmissivity of this zone (obtained from the John Mathes & Associates, Inc. aquifer test -  $165,000 \text{ gpd/ft}$ ) by its saturated thickness (50 feet). This method should provide a minimum permeability as the pumping well is screened over only a portion of the aquifer. The data from Table 10 were not used because all three tests were conducted in Madison County. The hydraulic gradient (0.0020) was determined from the August 1984 water-level map in areas unaffected by dewatering operations (Figure 9). The effective porosity was assumed to be 20 percent (Walton, 1984). Therefore, the calculated ground-water velocity is 4.4 feet per day (1,606 feet per year).

### Deep Zone

Ground-water velocity in the deep zone was determined to be 6.4 feet per day (2,350 feet per year). The hydraulic conductivity ( $4,200 \text{ gpd/ft}^2$ ) was determined by dividing the transmissivity value obtained during the 1952 aquifer test (Table 10) by the saturated thickness of 50 feet (90 to 140 feet below land surface). This value is higher than the permeability listed in Table 10 ( $2,800 \text{ gpd/ft}^2$ ) because

Schicht (1965) used 75 feet as the saturated thickness, rather than 50 feet. The hydraulic gradient (0.0023) was determined from the August 1984 water-level map in areas unaffected by dewatering operations (Figure 10). The effective porosity was assumed to be 20 percent (Walton, 1984).

### GROUND-WATER QUALITY

Ground-water sampling programs have been conducted at the Monsanto facility since November 1983 (Tables E-1 through E-5 in Appendix E). The overall objective of the monitoring programs was to characterize plant-wide ground-water quality. A minimum of two samples were collected from wells in critical areas. However, some wells have been sampled only once while others, such as GM-12A, were sampled frequently for quality assurance/quality control purposes.

Between November 1983 and May 1984, three rounds of samples were collected from the first 12 wells installed by Geraghty & Miller, Inc. The fourth sampling round was conducted in June, 1984 when ten wells in the landfill area were sampled. Each ground-water sample collected during the four sampling rounds was analyzed for USEPA priority pollutant compounds, with the exception of February 1984. Only total organic carbon (TOC), total organic halogens (TOX), total phenols and chloride were scheduled for this round. In addition to the priority pollutant analyses, TOC and TOX were determined in November 1983 and May 1984, and chloride was analyzed in the May 1984 program. Temperature, pH, and specific conductance (field parameters) were measured in the field during each round. Envirodyne Engineers (St. Louis, Missouri) provided the laboratory services for each of these sampling programs.

During the same period, D'Appolonia Waste Management Services, Inc. collected samples from the Monsanto Landfill monitoring wells in January, February, March, and May, 1984. Analyses were limited to TOC, TOX, total phenols, pH, temperature, and specific conductance. The analytical services were provided by D'Appolonia's laboratory in Pittsburgh, Pennsylvania.

In August 1984, a plant-wide sampling program was initiated by Geraghty & Miller, Inc. after additional wells were installed between June and August, 1984. The analytical program included a library search for non-priority pollutant compounds in addition to the USEPA Priority Pollutants. Miscellaneous constituents, such as TOC, chloride, and total dissolved solids (TDS), were also included in the program, as well as the three routine field parameters. In addition, three wells were selected for dioxin analysis (GM-16A, GM-27B and GM-28B). Envirodyne Engineers, Inc. also provided the laboratory services for this sampling program.

The analytical data for many samples collected during the August 1984 sampling round may be invalid because samples were held beyond the method holding times prior to analysis. Where there were questions regarding the integrity of the analytical data, wells were resampled in

November 1985. The questionable data are reported but are footnoted in the data tables.

Based on the results of the September 1984 library search and Monsanto's knowledge of past chemical usage in the plant, a list of non-priority pollutant compounds was developed for addition to the priority pollutant list. These compounds could theoretically be present in the ground water and were analyzed for in sampling rounds after September 1984. The chemicals are listed below:

Volatile Organic Compounds

Methyl-iso-butyl ketone  
Methyl-isoamyl ketone  
m-Xylene  
o-Xylene  
p-Xylene

Acid Extractable Organic Compounds

4-Chlorophenol

Base/Neutral Extractable Organic Compounds

2-Nitroaniline  
4-Nitroaniline  
2-Nitrochlorobenzene  
4-Nitrochlorobenzene  
2,4-Dinitrochlorobenzene  
3,4-Dinitrochlorobenzene  
4-Nitrodiphenylamine  
Triphenyl phosphate  
2-Nitrobiphenyl (Wells GM-8 and GM-31ABC only)  
4-Nitrobiphenyl (Wells GM-8 and GM-31ABC only)

Five sampling rounds were conducted between November 1984 and February 1986 for the USEPA priority pollutant compounds and the site specific list of non-priority pollutants. Environmental Testing and Certification (ETC) in



Edison, New Jersey provided the laboratory services for each of these programs and their results are presented in Tables E-1 through E-5 (Appendix E).

The chemical data base is extensive and would prove cumbersome to those not familiar with it. In order to present these data in a manner that will easily demonstrate where chemical constituents have and have not been detected, mean concentrations of total priority pollutants and identified non-priority pollutants have been calculated for each well. The organic fractions of the chemical analysis (i.e. volatile, base/neutral, acid, and pesticide/PCB compounds) were averaged individually and the mean value for each organic fraction was added together (Table 11). The results of the data reduction are presented for each of the three hydrogeologic zones, and are shown on Figures 23 through 25.

Laboratory results that are reported with a less than symbol (<) indicate that the chemical constituent was not detected above its detection limit (the value to the right of the symbol) at the time the analysis was performed. These results were assigned a value of zero for computations of means or averages. The detection limits for the same compounds vary between Envirodyne and ETC, as well as between sampling events analyzed by the same laboratory. This is due to different analytical equipment, the volume of sample analyzed and different levels of interferences.

The results of the USEPA priority pollutant metals analysis for each sampling round are provided in Table E-5 in Appendix E. Most results are below the method detection limits, and few analyses are above USEPA drinking water standards for the metals that were detected. Therefore, these data are presented only in tabular form.

Throughout the course of the ground-water sampling programs conducted at the W.G. Krummrich Plant, 10 to 15 percent of the total number of samples were submitted as blind replicates, and trip and field blanks were also collected for QA/QC purposes. The blanks were analyzed for volatile organic compounds only. Replicates from well GM-12A were collected during each sampling round, except September 1984, to provide a continuing check on laboratory performance. There are seven data sets for well GM-12A and they are shown in Table 12.

With the exceptions of the September and November, 1984 field blanks, trip blanks collected in May and September, 1984 and five laboratory blanks collected in September, 1984 (11 out of a total of 34), total volatile organic compound concentrations were less than 50 ug/L in the blanks (see Table E-1). Benzene, chlorobenzene and methylene chloride were compounds present in the highest concentrations in the blanks, with methylene chloride constituting more than 50%

of the total in most cases. Because these compounds were found in all three types of blanks which are made up from distilled/deionized water provided by the laboratory and these compounds are used for many purposes in the laboratory (especially methylene chloride which is a solvent and extractant), the presence of contaminants in the blanks is regarded as a laboratory artifact.

Table 13 shows that low concentrations of benzene (5 ug/L or below), chlorobenzene (5 ug/L or below) and methylene chloride (20 ug/L or below) in ground-water samples must be regarded as spurious because they are present in the blanks. The numbers in parentheses are the means of the mean concentration in each type of blank (see Table 13). Total volatile organic compound concentrations below approximately 30 ug/L in ground water must also be regarded as suspect because the analytical data for blanks indicates that there is very little confidence in the concentrations below this value (see Table 13).

The quality of laboratory performance was evaluated with replicate data from Well GM-12A according to procedures in EPA Method Study 29, Method 624 -- Purgeables (1984), one of several EPA Interlaboratory Method Validation Studies (IMVS) which provides information on the expected precision and accuracy for the method used on the Monsanto samples. This review, however, evaluated only precision as shown by

the closeness of values of replicate samples. Accuracy cannot be evaluated because the samples in question are field samples and not laboratory prepared reference samples.

Table 14 shows the replicate pairs of chlorobenzene, xylenes, toluene, benzene and ethylbenzene data that were evaluated for VOC precision and relative error. For each quantified constituent, Table 14 shows the range of concentrations that the IMVS data applies and the expected precision. With two exceptions, all the results have precision which fall inside the IMVS QC acceptance criteria. Some concentrations, such as those for toluene and ethylbenzene are only marginally outside the applicable range for the method. Most of the benzene data is outside the range. The fact that some concentrations are outside the applicable range does not reflect badly on the data because they meet the IMVS criteria based on distilled water and precision can be expected to be lower for environmental samples. In addition the relative error ranges from 0.4 to 33 percent and averages 8% (the mean of the means for each compound in Table 14) which indicates very good agreement among replicates. Overall, the performance of the laboratory was very good which indicates a high degree of confidence in the rest of the analytical data.

## TABLES

Table 1. Well Inventory of Off-Site Wells Located in the East St. Louis - Sauget - Cahokia Area, Illinois.

Well No.	Well Location	Date Completed	Depth (feet below land surface)	Well Diameter (inches)	Screen Setting (feet below land surface)	Status/Remarks
<u>Owner: Illinois Environmental Protection Agency</u>						
G101	2N-10W-26	10- 8-80	28.5	2	8.5- 28.5	IEPA Monitoring Well/Dead Creek Study
G102	do	10- 8-80	32.8	2	7.5- 32.8	do
G103	do	10- 9-80	32.8	2	6.2- 32.8	do
G104	do	10- 9-80	34.0	2	9.0- 34.9	do
G105	do	10-10-80	34.5	2	9.5- 34.5	do
G106	do	10-15-80	40.0	2	5.0- 40.0	do
G107	do	10-16-80	33.8	2	3.8- 33.8	do
G108	do	10-20-80	34.2	2	4.2- 34.2	do
G109	do	10-21-80	35.0	2	8.0- 35.0	do
G110	do	10-22-80	30.0	2	5.0- 30.0	do
G111	do	10-23-80	34.0	2	12.0- 34.0	do
G112	do	10-29-80	35.1	2	13.1- 35.1	do
<u>Owner: Private Wells</u>						
G501	2N-10W-256	- <sup>a)</sup>	-	-	-	Private Well/IEPA Creek Study
G502	do	-	-	-	-	do
G503	do	-	-	-	-	do
G504	do	-	-	-	-	do
<u>Owner: Amax Corporation<sup>b)</sup></u>						
5	2N-10W-23.3a	-	104	-	-	Supply Well

a) Data not available

b) Several monitoring wells exist on Amax's property but data is not available according to IEPA.

Table 1. (Cont'd.)

Well No.	Well Location	Date Completed	Depth (feet below land surface)	Well Diameter (inches)	Screen Setting (feet below land surface)	Status/Remarks
<u>Owner: Cerro Corporation</u>						
4	2N-10W-26	-	100-110	-	-	Supply Well
5	do	-	100-110	-	-	do
6	do	-	97	-	-	do
<u>Owner: Certainteed Products Co.</u>						
1	2N-9W-19.8f	-	122	-	-	do
2	do	-	110	-	-	do
3	do	-	106	-	-	do
<u>Owner: Chemtech</u>						
-	2N-9W-29.8f	-	-	-	-	do
<u>Owner: Fox Terminal</u>						
-	2N-10W-33.1f	-	105	-	-	do
<u>Owner: Illinois State Water Survey</u>						
-	2N-10W-35	-	-	-	-	-
R-2	2N-10W-26.8g	-	-	-	-	-
No. 20	2N-10W-25.5d	-	-	-	-	-
<u>Owner: Lefton</u>						
-	2N-10W-25.7b	-	-	-	-	Supply well

Table 1. (Cont'd.)

Well No.	Well Location	Date Completed	Depth (feet below land surface)	Well Diameter (inches)	Screen Setting (feet below land surface)	Status/Remarks
<u>Owner: Midwest Rubber Co.</u> c) d)						
2	2N-10W-26	-	114	-	-	Supply Well
6	do	-	110	-	-	do
7	do	-	109	-	-	do
8	do	-	112	-	-	do
10	do	-	115	-	-	do
11	do	-	115	-	-	do
<u>Owner: Mississippi Avenue Warehouse</u>						
-	2N-10W-23	-	-	-	-	do
<u>Owner: Mobil-Sacony</u>						
-	2N-10W-25.6E	-	-	-	-	do
<u>Owner: Obear-Nester Glass Company</u>						
-	2N-9W-19.7d	-	-	-	-	do
-	do	-	-	-	-	do
<u>Owner: Phillips Petroleum</u>						
-	2N-10W-34	-	-	-	-	do

c) Several monitoring wells exist on Midwest Rubber's property but data is not available according to IEPA.

d) Only four wells are shown on Figure 1 because the exact locations of the other 2 are unknown.



Table 1. (Cont'd.)

Well No.	Well Location	Date Completed	Depth (feet below land surface)	Well Diameter (inches)	Screen Setting (feet below land surface)	Status/Remarks
<u>Owner: U.S. Corps of Engineers</u>						
RW-111	2N-10W-23	-	-	-	-	Mississippi River Levee Relief Wells
RW-118	2N-10W-23.6f	-	-	-	-	do
RW-126	2N-10W-23	-	-	-	-	do
RW-136	do	-	-	-	-	do
RW-137	2N-10W-34.5h	-	-	-	-	do
RW-159	2N-10W-34	-	90	-	-	do
RW-169	do	-	78	-	-	do
RW-180	2N-10W-34.8b	-	82	-	-	do
RW-196	2N-10W-4.1g	-	-	-	-	do
<u>Owner: St. Louis Grain Co.</u>						
-	2N-9W-30	-	-	-	-	Supply Well
<u>Owner: Sterling Steel Casting Company</u>						
-	2N-10W-26	-	120	-	-	do
<u>Owner: Clayton Chemical Company</u>						
1	2N-10W-24	-	72	-	-	Supply Well
2	do	-	60.5	-	-	do
3	do	-	43.5	-	-	do
4	do	-	75	-	-	do

Table 2. Static Water Levels for Monitoring Wells Measured During August 24-27, 1984, Monsanto Company, W.G. Krummrich Plant, Sauget, Illinois.

Well No.	Well Depth (feet below land surface)	Elevation of the Measuring Point (feet above mean sea level)	Depth to Water (feet below measuring point)	Elevation of Water Level (feet above mean sea level)
<u>Geraghty &amp; Miller, Inc. Monitoring Wells</u>				
GM-1	34	413.65	12.93	400.72
GM-2	41	417.37	19.32	398.05
GM-3	36	411.31	15.15	396.16
GM-4A	28	406.43	9.15	397.28
GM-4B	87	406.70	10.10	396.60
GM-5	36	414.94	18.72	396.22
GM-6A	34	414.59	16.96	397.63
GM-6B	88	416.04	19.40	396.64
GM-7	36	414.95	18.05	396.90
GM-8	34	418.49	21.12	397.37
GM-9A	28	414.47	13.26	401.21
GM-9B	75	412.36	12.67	399.69
GM-9C	108	411.97	12.76	399.21
GM-10A	28	412.97	11.86	401.11
GM-11	25	412.95	12.80	400.15
GM-12A	33.5	416.47	15.99	400.48
GM-12B	89	416.80	16.09	400.71
GM-13	38	415.47	15.25	400.22
GM-14	38	411.26	9.50	401.76
GM-15	38	413.71	13.53	400.18
GM-16A	38	412.03	12.83	399.20
GM-16B	90	412.40	13.22	399.18
GM-17A	38	412.57	14.07	398.50
GM-17B	78	412.93	14.77	398.16
GM-17C	107	412.42	14.61	397.81
GM-18A	38	414.23	17.22	397.01
GM-18B	92	414.02	17.16	396.86

Table 2. (Continued)

Well No.	Well Depth (feet below land surface)	Elevation of the Measuring Point (feet above mean sea level)	Depth to Water (feet below measuring point)	Elevation of Water Level (feet above mean sea level)
<u>Geraghty &amp; Miller, Inc. Monitoring Wells</u> (Cont'd)				
GM-25A	38	414.20	19.30	394.90
GM-25B	88	415.46	21.62	393.84
GM-27B	82	426.04	37.24	388.80
GM-27C	105	426.76	38.86	387.90
GM-28B	93	423.88	34.10	389.78
GM-28C	107	423.78	34.21 <sub>a)</sub>	389.57
GM-29	20.5	411.06	- <sub>a)</sub>	-
GM-30	21.2	416.09	- <sub>a)</sub>	-
<u>Landfill Monitoring Wells</u>				
B-21A	28	428.53	27.74	400.79
B-21B	49.5	428.37	39.84	388.53
B-22A	35	428.16	26.72	401.44
B-22B	55	428.16	39.90	388.26
B-23B	49.5	428.17	39.50	388.67
B-24A	27.5	422.49	20.58	401.91
B-24B	50	422.28	32.81	389.47
B-24C	69	422.52	33.16	389.36
B-25A	35.2	428.47	26.88	401.59
B-25B	49.5	427.35	36.52	390.83
B-26A	33.2	423.71	24.59	399.12
B-26B	49.8	423.62	33.69	389.93
B-27B	42	425.83	34.19	391.64
B-28A	32.5	423.04	21.50	401.54
B-28B	49.5	423.08	32.49	390.59
B-29A	33.2	429.03	28.56	400.47
B-29B	49.5	429.06	36.86	392.20
B-30B	49	430.52	38.90	391.62
B-31B	34.5	421.68	33.76	387.92
B-31C	67.3	421.88	34.87	387.01
B-101	169.2	427.09	38.44	388.65
B-102	162	423.84	34.45 <sub>b)</sub>	389.39
B-103	165.8	427.33	- <sub>b)</sub>	-
B-105	154	420.93	- <sub>b)</sub>	-

Table 2. (Continued)

Well No.	Well Depth (feet below land surface)	Elevation of the Measuring Point (feet above mean sea level)	Depth to Water (feet below measuring point)	Elevation of Water Level (feet above mean sea level)
<u>Landfill Monitoring Wells (Cont'd)</u>				
P-1	47	423.11	32.96	390.15
P-2	47	423.15	33.21	389.94
P-3	47	423.43	33.56	389.87
P-4	47.5	421.82	31.99	389.83
P-5	54.5	422.12	32.75	389.37
P-6	30.5	421.78	24.54	397.24
P-7	33	421.82	22.31	399.51
P-8	53.5	421.79	32.65	389.14
P-9	50	423.14	34.13	389.01
P-10	54	423.43	34.13	389.30
P-11	51	422.30	33.76	388.54
P-12	50.5	423.75	35.18	388.57
P-13	53.5	424.32	36.51	387.81
P-14	32.5	424.36	23.72	400.64
<u>Dewatering Wells in the Plant Area</u>				
DW-1	65	410.04	11.91	398.13
DW-2	65	409.12	10.89	398.23
DW-3	65	408.85	10.41	398.44
DW-4	65	408.44	10.59	397.85
DW-5	65	-	- c)	-
DW-6	65	-	- c)	-
DW-7	65	-	- c)	-
DW-8	65	-	- c)	-
DW-9	65	-	- c)	-
DW-10	65	409.40	9.91	399.49
DW-11	65	-	- c)	-
DW-12	65	-	- c)	-
DW-13	65	-	- c)	-
DW-14	65	-	- c)	-
DW-15	65	-	- c)	-
DW-16	65	-	- c)	-
BK-1	66	408.36	4.11	404.25
BK-2	25	409.67	8.46	401.21

Table 2. (Continued)

Well No.	Well Depth (feet below land surface)	Elevation of the Measuring Point (feet above mean sea level)	Depth to Water (feet below measuring point)	Elevation of Water Level (feet above mean sea level)
<u>Monitoring Wells in the Plant Area for Dewatering Projects</u>				
M-2	40	410.38	12.00	398.38
M-4	29	409.18	9.85	399.33
M-7	29	410.67	9.60	401.07
BK-3	66	415.24	15.23	400.01
DW-34	25	414.67	16.15	398.52
<u>Dewatering Wells for the Treatment Plant Sewer Construction</u>				
DW-17	80	422.99	-d)	-
DW-18	80	-	-d)	-
DW-19	80	426.88	-d)	-
DW-23	80	422.80	35.05	387.75
DW-23A	80	419.68	30.41	389.27
DW-24	80	427.30	37.85	389.45
DW-25	80	415.79	27.19	388.60
<u>Monitoring Wells for the Treatment Plant Dewatering Projects</u>				
DW-27	30	429.68	31.49	398.19
DW-28	30	427.86	31.58	396.28
DW-29	68	424.89	37.17	387.72
DW-30	31	422.77	34.49	388.28
DW-31	25	423.71	-e)	-
DW-32	66	432.57	43.47	389.10
DW-33	30	416.23	20.78	395.45
<u>U.S. Corps of Engineers Monitoring Wells</u>				
P-56	35	430.98	38.30	392.68
P-58	35	414.47	-e)	-
P-59	35	414.51	-b)	-
P-65	32	426.50	-e)	-
P-68	35	432.58	-e)	-

Table 2. (Continued)

Well No.	Well Depth (feet below land surface)	Elevation of the Measuring Point (feet above mean sea level)	Depth to Water (feet below measuring point)	Elevation of Water Level (feet above mean sea level)
<u>Offsite Wells (East of Town Hall)</u>				
WB-6	30	406.49	5.65	400.84
WB-7	80	406.85	6.05	400.80
WB-8	30	409.52	-b)	-
WB-9	80	407.43	6.74	400.69

- a) Well was installed after water-level measurements were made.
- b) Not measured.
- c) Inaccessible.
- d) Well was pumping, water-level could not be determined.
- e) Dry.

Table 3. Static Water Levels for Monitoring Wells Measured During November 21-22, 1985, Monsanto Company, W.G. Krummrich Plant, Sauget, Illinois.

Well No.	Well Depth (feet below land surface)	Elevation of the Measuring Point (feet above mean sea level)	Depth to Water (feet below measuring point)	Elevation of Water Level (feet above mean sea level)
<u>Geraghty &amp; Miller, Inc. Monitoring Wells</u>				
GM-1	34	413.65	15.98	397.62
GM-2	41	417.37	23.12	394.25
GM-3	36	411.31	16.35	394.96
GM-4A	28	406.43	11.98	394.45
GM-4B	87	406.70	12.00	394.70
GM-4C	104	406.51	11.78	394.73
GM-5	36	414.94	20.82	394.12
GM-6A	34	414.59	20.20	394.39
GM-6B	88	416.04	21.65	394.39
GM-7	36	414.95	19.87	395.08
GM-8	34	418.49	22.95	395.54
GM-9A	28	414.47	18.80	395.57
GM-9B	75	412.36	27.04	390.32
GM-9C	108	411.97	20.03	391.94
GM-10A	28	412.97	14.85	398.12
GM-10B	78	413.90	18.11	395.79
GM-10C	111	413.78	18.11	395.67
GM-11	25	412.95	15.95	397.00
GM-12A	33.5	416.47	20.12	396.35
GM-12B	89	416.80	20.09	396.71
GM-12C	114.5	416.79	20.01	396.78
GM-13	38	415.47	21.70 <sub>a)</sub>	393.77
GM-14	38	411.26	-	-
GM-15	38	413.71	17.18	396.53
GM-16A	38	412.03	15.38	396.65
GM-16B	90	412.40	15.73	396.67
GM-17A	38	412.57	17.60	394.97
GM-17B	78	412.93	18.01	394.92
GM-17C	107	412.42	17.26	395.16

Table 3. (Continued)

Well No.	Well Depth (feet below land surface)	Elevation of the Measuring Point (feet above mean sea level)	Depth to Water (feet below measuring point)	Elevation of Water Level (feet above mean sea level)
<u>Geraghty &amp; Miller, Inc. Monitoring Wells (Cont'd.)</u>				
GM-18A	38	414.23	18.77	395.46
GM-18B	92	414.02	18.48	395.54
GM-25A	38	414.20	14.35	399.85
GM-25B	88	415.46	15.46	400.00
GM-27B	82	426.04	18.68	407.36
GM-27C	105	426.76	20.13	406.63
GM-28B	93	423.88	18.60	405.28
GM-28C	107	423.78	18.80	404.98
GM-29	20.5	411.06	12.88	398.18
GM-30	21.2	416.09	18.85	397.24
GM-31A	40	418.63	22.99	395.64
GM-31B	94	418.92	23.32	395.60
GM-31C	126.5	419.29	23.46	395.83
GM-32	25	409.49	-a)	-
GM-33	25	410.88	-a)	-
GM-34	25	410.82	-a)	-
GM-35	25	410.88	-a)	-
GM-36	25	409.53	-a)	-
GM-37	25	409.67	-a)	-
GM-38	25	412.51	17.41	395.10
GM-39	8	415.59	-a)	-
GM-40	8	415.75	-a)	-
GM-41	8	414.75	-a)	-
GM-42	8	414.48	-a)	-
GM-43	8	414.38	-a)	-
GM-44	8	414.44	-a)	-
GM-45	18	410.10	2.69	407.41
GM-46	25	411.60	11.26	400.34
GM-47	10	412.34	-a)	-
GM-48	12	411.00	4.04	406.96
GM-49	13	408.43	1.90	406.53
GM-106	165.7	424.82	20.29	404.53



Table 3. (Continued)

Well No.	Well Depth (feet below land surface)	Elevation of the Measuring Point (feet above mean sea level)	Depth to Water (feet below measuring point)	Elevation of Water Level (feet above mean sea level)
<u>Landfill Monitoring Wells</u>				
B-21A	28	428.53	29.42	399.11
B-21B	49.5	428.37	29.97	398.40
B-22A	35	428.16	23.38	404.78
B-22B	55	428.16	23.35	404.81
B-23B	49.5	428.17	25.19	402.98
B-24A	27.5	422.49	17.38	405.11
B-24B	50	422.28	17.32	404.96
B-24C	69	422.52	17.39	405.13
B-25A	35.2	428.47	31.13	397.34
B-25B	49.5	427.35	26.67	400.68
B-26A	33.2	423.71	20.25	403.46
B-26B	49.8	423.62	18.48	405.14
B-27B	42	425.83	22.93	402.90
B-28A	32.5	423.04	21.47	401.57
B-28B	49.5	423.08	18.38	404.70
B-29A	33.2	429.03	29.97	399.06
B-29B	49.5	429.06	27.61	401.45
B-30B	49	430.52	29.17	401.35
B-31B	34.5	421.68	22.32	399.36
B-31C	67.3	421.88	22.43	399.45
B-101	169.2	427.09	29.14	397.95
B-102	162	423.84	22.47	401.37
B-103	165.8	427.33	24.82	402.51
B-105	154	420.93	19.02	401.91
P-1	47	423.11	17.40	405.71
P-2	47	423.15	17.27	405.88
P-3	47	423.43	17.57	405.86
P-4	47.5	421.82	16.01	405.81
P-5	54.5	422.12	15.81	406.31
P-6	30.5	421.78	12.79	408.99
P-7	33	421.82	13.79	408.03
P-8	53.5	421.79	15.15	406.64
P-9	50	423.14	16.38	406.76
P-10	54	423.43	16.55	406.88

Table 3. (Continued)

Well No.	Well Depth (feet below land surface)	Elevation of the Measuring Point (feet above mean sea level)	Depth to Water (feet below measuring point)	Elevation of Water Level (feet above mean sea level)
<u>Landfill Monitoring Wells (Cont'd.)</u>				
P-11	51	422.30	15.14	407.16
P-12	50.5	423.75	16.08	407.67
P-13	53.5	424.32	16.62	407.70
P-14	32.5	424.36	13.50	410.86
<u>Dewatering Wells in the Plant Area</u>				
DW-1	65	410.04	16.45	393.59
DW-2	65	409.12	-b)	-
DW-3	65	408.85	-b)	-
DW-4	65	408.44	-b)	-
DW-5	65	-	-b)	-
DW-6	65	-	-b)	-
DW-7	65	-	18.87	-
DW-8	65	-	-c)	-
DW-9	65	-	-c)	-
DW-10	65	409.40	-c)	-
DW-11	65	-	-c)	-
DW-12	65	-	-b)	-
DW-13	65	-	-b)	-
DW-14	65	-	-b)	-
DW-15	65	-	-b)	-
DW-16	65	-	-b)	-
BK-1	25	408.36	5.30	403.06
BK-2	25	409.67	12.75	396.92
<u>Monitoring Wells in the Plant Area for Dewatering Projects</u>				
BK-3	66	415.24	19.43	395.81
DW-34	25	414.67	19.45	395.22

Table 3. (Continued)

Well No.	Well Depth (feet below land surface)	Elevation of the Measuring Point (feet above mean sea level)	Depth to Water (feet below measuring point)	Elevation of Water Level (feet above mean sea level)
<u>Dewatering Wells for the Treatment Plant Sewer Construction</u>				
DW-1-85	80	414.40	- <sup>b)</sup>	-
DW-17	80	422.99	15.18	407.81
DW-18	80	426.10	19.46	406.64
DW-19	80	426.88	21.91	404.97
<u>Monitoring Wells for the Treatment Plant Dewatering Projects</u>				
DW-27	30	429.68	23.24 <sup>a)</sup>	406.44
DW-28	30	427.86	- <sup>a)</sup>	-
DW-29	68	424.89	23.51	401.38
DW-30	31	422.77	23.77	399.00
DW-31	25	423.71	24.82 <sup>a)</sup>	398.89
DW-32	66	432.57	- <sup>a)</sup>	-
DW-33	30	416.23	- <sup>a)</sup>	-
DW-15-85	65	413.76	20.48	393.28
<u>U.S. Corps of Engineers Monitoring Wells</u>				
P-56	35	430.98	- <sup>a)</sup>	-
P-58	35	414.47	- <sup>a)</sup>	-
P-59	35	414.51	- <sup>a)</sup>	-
P-65	32	426.50	26.82	399.68
P-68	35	432.58	33.35	399.23
<u>Offsite Wells (East of Town Hall)</u>				
WB-6	30	406.49	9.28	397.21
WB-7	80	406.85	9.89 <sup>a)</sup>	396.96
WB-8	30	409.52	- <sup>a)</sup>	-
WB-9	80	407.43	- <sup>a)</sup>	-

a) Not measured

b) Inaccessible

c) Well was pumping, water level could not be determined.

Table 4. Summary of Construction Details for Monitoring Wells Installed Under the Direction of Geraghty & Miller, Inc., Monsanto Company, W.G. Krummrich Plant, Sauget, Illinois.

Well No.	Date Completed	Well Diameter (inches)	Depth (feet below land surface)	Screen Setting (feet below land surface)	Interval Gravel Packed (feet below land surface) <sup>1)</sup>	Interval Sealed With Bentonite (feet below land surface)	Interval Sealed with Grout (feet below land surface) <sup>2)</sup>	Height of measuring Point (feet above land surface) <sup>3)</sup>	Elevation of measuring Point (feet above mean sea level) <sup>4)</sup>
GM-1	11- 1-83	6	34	19 - 34	16 - 28	15 - 16	2 - 15	2.6 (2.3) <sup>5)</sup>	413.65
GM-2	11- 8-83	6	41	26 - 41	None	21 - 22	2 - 21	2.2 (2.0) <sup>5)</sup>	417.37
GM-3	11- 7-83	6	36	21 - 36	19 - 24	18 - 19	2 - 18	3.9 (3.7) <sup>5)</sup>	411.31
GM-4A	11- 2-83	2	28	13 - 28	12 - 14	11 - 12	2 - 11	2.8	406.43
GM-4B	7-17-84	4	87	67 - 87	65 - 87	55 - 65	2 - 65	3.0	406.70
GM-4C	1-11-84	4	104	92.5-102.5	90 -102.5	75 - 90	2 - 75	2.5	406.51
GM-5	11- 3-83	2	36	21 - 36	18.5- 24	17.5- 18.5	2 - 17.5	2.5	414.94
GM-6A	11- 2-83	2	34	19 - 34	16 - 22	15 - 16	2 - 15	2.0	414.59
GM-6B	7-26-84	4	88	68 - 88	62.5- 88	47.5-62.5	6 - 47.5	3.1	416.04
GM-7	11- 3-83	2	36	21 - 36	17 - 23	16 - 17	2 - 16	2.5	414.95
GM-8	11- 2-83	2	34	19 - 34	None	15 - 16	2 - 15	2.0	418.49
GM-9A	11-10-83	2	28	13 - 28	11.5- 15.5	10.5- 11.5	2 - 10.5	2.7	414.47
GM-9B	8-17-84	4	75	55 - 75	50 - 75	38 - 50	2 - 38	1.9	412.36
GM-9C	8-15-84	4	108	88 -108	84 -108	70 - 84	2 - 70	1.5	411.97
GM-10A	11- 9-83	2	28	13 - 28	11 - 12.5	10 - 11	2 - 10	2.2	412.97
GM-10B	1-22-85	4	78	54 - 74	48 - 74	38 - 48	2 - 38	2.5	413.90
GM-10C	1-18-85	4	111	94 -109	85 -109	75 - 85	2 - 75	2.5	413.78

Table 4. (Cont'd.)

Well No.	Date Completed	Well Diameter (inches)	Depth (feet below land surface)	Screen Setting (feet below land surface)	Interval Gravel Packed (feet below land surface) <sup>1)</sup>	Interval Sealed With Bentonite (feet below land surface)	Interval Sealed with Grout (feet below land surface) <sup>2)</sup>	Height of Measuring Point (feet above land surface) <sup>3)</sup>	Elevation of Measuring Point (feet above mean sea level) <sup>4)</sup>
GM-11	10-31-83	2	25	10 - 25	8.5- 21	7.5- 8.5	2 - 7.5	2.6	412.95
GM-12A	11- 9-83	2	33.5	18.5- 33.5	16 - 23	15 - 16	2 - 15	3.0	416.47
GM-12B	8-13-84	4	89	69 - 89	65 - 89	50 - 65	2 - 50	2.6	416.80
GM-12C	1-17-85	4	114.5	94 -114.5	90 -114	75 - 90	2 - 75	2.5	416.79
GM-13	8-15-84	2	38	18 - 38	16 - 38	15 - 16	2 - 15	2.0	415.47
GM-14	8-16-84	2	38	18 - 38	16 - 38	15 - 16	2 - 15	2.5	411.26
GM-15	8-17-84	2	38	15 - 38	12.5- 38	11.5- 12.5	2 - 11.5	2.0	413.71
GM-16A	8-14-84	2	38	18 - 38	16 - 38	15 - 16	2 - 15	2.1	412.03
GM-16B	8- 9-84	4	90	60 - 87	56 - 68	42 - 46	2 - 42	2.0	412.40
GM-17A	7- 6-84	2	38	18 - 38	16 - 38	15 - 16	2 - 15	3.0	412.57
GM-17B	7-25-84	4	78	58 - 78	52.5- 78	42 - 52.5	2 - 42	3.0	412.93
GM-17C	7-24-84	4	107	87 -107	80 -107	70 - 80	2 - 70	3.2	412.42
GM-18A	7- 5-84	2	38	18 - 38	16 - 38	15 - 16	2 - 15	2.6	414.23
GM-18B	7-12-84	2	92	72 - 92	68 - 92	56 - 68	2 - 56	2.8	414.02
GM-25A	8-14-84	2	38	13 - 38	10 - 38	9 - 10	2 - 9	1.4	414.20
GM-25B	7-27-84	4	88	68 - 88	62 - 88	47 - 62	2 - 47	3.0	415.46
GM-27B	8- 6-84	4	82	62 - 82	55 - 72	45 - 55	2 - 45	2.8	426.04 (425.61) <sup>ε</sup>
GM-27C	8- 3-84	4	105	85 -105	80 -115	68 - 80	2 - 80	2.9	426.76 (426.39) <sup>ε</sup>

Table 4. (Cont'd.)

[illegible]

Table 4. (Cont'd.)

Well No.	Date Completed	Well Diameter (inches)	Depth (feet below land surface)	Screen Setting (feet below land surface)	Interval Gravel Packed (feet below land surface) <sup>1)</sup>	Interval Sealed With Bentonite (feet below land surface)	Interval Sealed with Grout (feet below land surface) <sup>2)</sup>	Height of Measuring Point (feet above land surface) <sup>3)</sup>	Elevation of Measuring Point (feet above mean sea level) <sup>4)</sup>
GM-46	12- 7-84	2	25	5 - 25	4 - 25	3 - 4	2 - 2.3	2.6	411.60
GM-47	12-10-84	2	10	5 - 10	4 - 10	3 - 4	1.5- 3	-0.45	412.34
GM-48	12-10-84	2	12	2 - 12	1.9- 12	1.5- 9	0.5- 1.5	1.4	411.00
GM-49	12-10-84	2	13	3 - 13 <sup>7)</sup>	2.5- 13	2 - 2.5	0.5- 2	-0.4	408.43 <sup>8)</sup>
GM-106	6-27-85	8	165.7	None	None	None	0 -133.5	1.2	424.82 <sup>8)</sup>

- 1) Gravel pack is absent in some wells and partially covers the screened interval in others due to a collapse of the natural formation around the well prior to setting the gravel pack.
- 2) The grout was mixed with 90 percent cement and 10 percent bentonite and each well has a cement seal at the surface.
- 3) The measuring point on each well is the top of the well casing and not the protective outer casing. For each well that has a water-level recorder, the measuring point is the top of the water-level recorder shelter base, except on Well B-106.
- 4) The elevations were determined to the top of the steel well casings for each well and to the top of the recorder shelter base for the wells installed with water-level recorders. The conversions to the W.G. Krummrich datum is 413.50 feet (NGVD) equals 101.00 feet (W.G. Krummrich datum).
- 5) Height of the 6-inch casing above land surface.
- 6) Elevation of the top of the coupling.
- 7) Rock was encountered at 126 feet below land surface and an open hole exists from 133.5 to 165.7 feet below land surface. The 8-inch casing was grouted 7.5 feet into the rock inside a 12-inch casing which is set at the rock surface.
- 8) Elevation of the top of the well casing and not the recorder shelter base.

Table 5. Summary of Construction Details for Monitoring Wells Installed Under the Direction of D'Appolonia Waste Management Services, Inc. Monsanto Company, W.G. Krummrich Plant, Sauget, Illinois

Well No.	Date Completed	Well Diameter (inches)	Depth (feet below land surface)	Screen Setting (feet below land surface) <sup>1)</sup>	Interval Gravel Packed (feet below land surface) <sup>2)</sup>	Interval Sealed With Bentonite (feet below land surface)	Interval Sealed with Grout (feet below land surface) <sup>3)</sup>	Height of Measuring Point (feet above land surface) <sup>4)</sup>	Elevation of Measuring Point (feet above mean sea level) <sup>5)</sup>
B-21A	3-14-82	4	28	20.8- 25.8	None	13 - 19	0 - 13	2.0	428.53
B-21B	3-13-82	4	49.5	37.3- 47.3	None	28.5- 34.5	0 - 28.5	1.8	428.37
B-22A	3-15-82	4	35	27.8- 32.8	26 - 34	20 - 26	0 - 20	1.9	428.16
B-22B	3-13-82	4	55	42.8- 52.8	None	35 - 41	0 - 35	2.1	428.16
B-23B	3-16-82	4	49.5	42.3- 47.3	40.5- 48	34.5- 40.5	0 - 34.5	2.1	428.17
B-24A	3-20-82	4	27.5	20.3- 25.3	None	12 - 18	0 - 12	2.0	422.49
B-24B	3-19-82	4	50	37.8- 47.8	None	30.5- 36.5	0 - 30.5	1.9	422.28
B-24C	3-18-82	4	69	56.8- 66.8	None	31-37/52-55	0 - 31	1.7	422.52
B-25A	3-31-82	4	35.2	28 - 33	25.9- 34.1	19 - 25.9	0 - 19	1.8	428.47
B-25B	3-17-82	4	49.5	37.3- 47.3	None	30 - 36	0 - 30	2.0	427.35
B-26A	3-23-82	4	33.2	26 - 31	24 - 29	17 - 24	0 - 17	1.9	423.71
B-26B	3-22-82	4	49.8	37.6- 47.6	36 - 49.8	28 - 36	0 - 28	2.0	423.62
B-27B	3-24-82	4	42	29.8- 39.8	28 - 36	20 - 28	0 - 20	1.8	425.83
B-28A	3-26-82	4	32.5	25.3- 30.3	23.1- 31	16 - 23.1	0 - 16	1.6	423.04
B-28B	3-26-82	4	49.5	37.3- 47.3	34.8- 37	28 - 34.8	0 - 28	1.8	423.08



Table 5. (Cont'd.)

Well No.	Date Completed	Well Diameter (inches)	Depth (feet below land surface)	Screen Setting (feet below land surface) <sup>1)</sup>	Interval Gravel Packed (feet below land surface) <sup>2)</sup>	Interval Sealed With Bentonite (feet below land surface)	Interval Sealed with Grout (feet below land surface) <sup>3)</sup>	Height of Measuring Point (feet above land surface) <sup>4)</sup>	Elevation of Measuring Point (feet above mean sea level) <sup>5)</sup>
B-29A	4- 1-82	4	33.2	26 - 31	23.4- 32	17 - 23.4	0 - 17	1.9	429.03
B-29B	3-27-82	4	49.5	37.3- 47.3	None	28 - 35	0 - 28	1.7	429.06
B-30B	3-29-82	4	49	36.8- 46.8	33.7- 38.6	27 - 33.7	0 - 27	2.2	430.52
B-31B	4- 2-82	4	34.5	27.3- 32.3	None	18.5- 24.7	0 - 18.5	1.5	421.68
B-31C	4- 6-82	4	67.3	60.1- 65.1	None	30 - 54	0 - 30	2.2	421.88
B-101	12- 9-83	0.75	169.2 <sup>6)</sup>	167.7-169.2	154 -169.2	153 -154	0 -153	2.4	427.09
B-102	12- 5-83	0.75	162.0 <sup>7)</sup>	159.5-162.0	147 -162	146 -147	0 -146	2.1	423.84
B-103	11-17-83	0.75	165.8 <sup>8)</sup>	163.0-165.5	149 -165.8	145.5-149	0 -145.5	0.7	427.33
B-105	11- 2-83	0.75	154.0 <sup>9)</sup>	151.5-154.0	134 -154	133 -134	0 -133	0.2	420.93

1) Each well has a 2.2-foot sump (well casing) below the screen setting.

2) Coarse sand was added to each annulus whenever the formation did not collapse around the well screen.

3) The grout consisted of a mixture of bentonite and cement.

4) The measuring point on each well is the top of the steel well casing and not the protective outer casing.

5) The elevations were determined to the top of the steel well casings.

6) The top of rock was encountered at 148.5 feet below land surface.

7) The top of rock was encountered at 142.5 feet below land surface.

8) The top of rock was encountered at 144.5 feet below land surface.

9) The top of rock was encountered at 131.0 feet below land surface.

Table 6. Summary of Construction Details for Monitoring Wells Installed Under the Direction of Law Engineering Testing Company, Monsanto Company, W.G. Krummrich Plant, Sauget, Illinois

Well No.	Date Completed	Well Diameter (inches)	Depth (feet below land surface)	Screen Setting (feet below land surface) <sup>1)</sup>	Interval Gravel Packed (feet below land surface) <sup>2)</sup>	Interval Sealed With Bentonite (feet below land surface) <sup>3)</sup>	Interval Sealed with Grout (feet below land surface) <sup>4)</sup>	Height of Measuring Point (feet above land surface) <sup>5)</sup>	Elevation of Measuring Point (feet above mean sea level) <sup>6)</sup>
P- 1	1-20-82	2	47	40 - 45	-	-	0 - 40	1.8	405.71
P- 2	1-26-82	2	47	40 - 45	-	-	0 - 40	1.5	405.88
P- 3	2-18-82	2	47	40 - 45	-	-	0 - 40	1.4	405.86
P- 4	3- 4-82	2	47.5	40.5- 45.5	-	-	0 - 40.5	1.7	405.81
P- 5	3 -5-82	2	54.5	47.5- 52.5	-	-	0 - 47.5	2.5	406.31
P- 6	3- 9-82	2	30.5	23.5- 28.5	-	-	0 - 23.5	1.7	408.99
P- 7	3- 8-82	2	33	26 - 31	-	-	0 - 26	1.6	408.03
P- 8	3- 2-82	2	53.5	46.5- 51.5	-	-	0 - 46.5	1.7	406.64
P- 9	3- 1-82	2	50	43 - 48	-	-	0 - 43	2.1	406.76
P-10	2-23-82	2	54	47 - 52	-	-	0 - 47	1.9	406.88
P-11	3- 6-82	2	51	44 - 49	-	-	0 - 44	1.8	407.16
P-12	2-22-82	2	50.5	43.5- 48.5	-	-	0 - 43.5	2.1	407.67
P-13	2-21-82	2	53.5	46.5- 51.5	-	-	0 - 46.5	1.8	407.70
P-14	3- 7-82	2	32.5	25.5- 30.5	-	-	0 - 25.5	2.0	410.86

1) Each well has a 2-foot sump (well casing) below the screen setting.

2) Silica sand was added to each annulus whenever the formation did not collapse around the well screen. Specific details for each well were not included in Law Engineering's well construction details.

3) Ten gallons of a thick bentonite slurry was set above the silica sand/natural formation in each well prior to sealing the wells with grout.

4) The grout was mixed with 90 percent cement and 10 percent bentonite.

5) The measuring point on each well is the top of the steel well casing and not the protective outer casing.

6) The elevations were determined to the top of the steel well casings.

**Table 7.** Water-Level Measurements for Determining Aquifer Characteristics Based on Slug Tests Performed on Wells GM-1, GM-2 and GM-3, Monsanto Company, W.G. Krummrich Plant, Sauget, Illinois.

Time (sec)	Well GM-1			Well GM-2			Well GM-3		
	Depth to Water*	H <sup>a)</sup>	H/H <sub>0</sub> <sup>b)</sup>	Depth to Water*	H	H/H <sub>0</sub>	Depth to Water*	H	H/H <sub>0</sub>
static	27.32	-	-	35.62	-	-	31.26	-	-
0	25.30 <sup>c)</sup>	2.02	1.00	33.60 <sup>c)</sup>	2.02	1.00	29.24 <sup>c)</sup>	2.02	1.00
15	25.83	1.49	0.74	33.91	1.71	0.85	29.62	1.64	0.82
30	26.03	1.29	0.64	33.99	1.63	0.81	29.72	1.54	0.76
45	26.18	1.14	0.56	34.05	1.57	0.78	29.78	1.48	0.73
60	26.29	1.03	0.51	34.09	1.53	0.76	29.84	1.42	0.70
75	26.38	0.94	0.47	34.13	1.49	0.74	29.89	1.37	0.68
90	26.46	0.86	0.43	34.16	1.46	0.72	29.94	1.32	0.65
105	26.53	0.79	0.39	34.19	1.43	0.71	29.98	1.28	0.63
120	26.60	0.72	0.36	34.22	1.40	0.69	30.02	1.24	0.61
135	26.66	0.66	0.33	34.25	1.37	0.68	30.06	1.20	0.59
150	26.72	0.60	0.30	34.28	1.34	0.66	30.10	1.16	0.57
165	26.77	0.55	0.27	34.31	1.31	0.65	30.13	1.13	0.56
180	26.82	0.50	0.25	34.34	1.28	0.63	30.17	1.09	0.54
195	26.86	0.46	0.23	34.37	1.25	0.62	30.21	1.05	0.52
210	26.89	0.43	0.21	34.39	1.23	0.61	30.24	1.02	0.50
225	26.91	0.41	0.20	34.41	1.21	0.60	30.27	0.99	0.49
240	26.93	0.39	0.19	34.43	1.19	0.59	30.30	0.96	0.48
255	-	-	-	34.45	1.17	0.58	30.32	0.94	0.47
270	-	-	-	34.47	1.15	0.57	30.35	0.91	0.45
285	-	-	-	34.49	1.13	0.56	30.38	0.88	0.44
300	-	-	-	34.50	1.12	0.55	30.40	0.86	0.43
315	-	-	-	34.51	1.11	0.55	30.43	0.83	0.41
330	-	-	-	-	-	-	30.46	0.80	0.40
345	-	-	-	-	-	-	30.48	0.78	0.39
360	-	-	-	-	-	-	30.50	0.76	0.38
375	-	-	-	-	-	-	30.52	0.74	0.37
390	-	-	-	-	-	-	30.54	0.72	0.36

**Note:**

\* Feet below top of well casing.

a) H - head inside the well at time t after injection of the slug (steel weight) above the initial head.

b) H<sub>0</sub> - head inside the well above the initial head at instant of injection of the slug (steel weight).

c) The increase of head at the instant of lowering the slug (steel weight) into the water table is equal to 2.02 feet.

Table 8. Summary of Slug Test Results for Selected Water-Table Zone Wells,  
Monsanto Company, W.G. Krummrich Plant, Sauget, Illinois.

Well	Transmissivity (gallons per day per foot)	Hydraulic Conductivity (gallons per day per square foot)	Storage Coefficient (dimensionless)	Portion of Screen that is Gravel-Packed (percent)
GM-1	344.3	23.0	0.01	60
GM-2	28.5	1.9	0.1	0
GM-3	51.8	3.5	0.1	20
Average	141.5	9.5	0.07	--

Table 9. Laboratory and Field Permeability Test Results Performed by D'Appolonia Waste Management Services, Inc. Monsanto Company, W.G. Krummrich Plant, Sauget, Illinois.

Boring No.	Depth (feet)	Permeability		Material
		cm/sec	gpd/sq ft	
<u>Field Test Results</u>				
B- 1	10.5	$1.8 \times 10^{-4}$	3.8	Silty clay
B-10	35.5	$6.0 \times 10^{-3}$	127.2	Silty clay
B-11	25.5	$2.0 \times 10^{-3}$	42.4	Sandy silt
B-15	45.5	$1.4 \times 10^{-3}$	29.7	Silty clay
<u>Laboratory Test Results</u>				
B -2	23 -25.5	$1.7 \times 10^{-7}$	0.004	Interbedded silty clay, silty fine sand and clayey silt
B-11	21.0-23.5	$4.1 \times 10^{-4}$	8.7	Fine sand, some silt
B-14	15.5-18.0	$1.2 \times 10^{-6}$	0.025	Sandy silt to silty sand, trace of clay
B-20	18.0-20.5	$5.2 \times 10^{-7}$	0.011	Interbedded silty clay, clayey silt, silty sand

Table 10. Aquifer Characteristics Based on Aquifer Tests in Madison and St. Clair Counties, Illinois<sup>a)</sup>

Owner	Location of Test Site	Test Date	Well Depth (feet)	Well Diameter (inches)	Well Screen Interval (feet below land surface)	Duration of Test (days)	Pumping Rate (gpm)	Transmissivity Coefficient (gpd/ft)	Saturated Thickness (feet)	Permeability Coefficient (gpd/sq ft)	Storage Coefficient
Olin Mathieson Chemical Corp.	Madison County T5N, R9W sec 19	May 29-June 1, 1956	88	12	78-88	3	760	95,600	90	1,060	0.135
City of Wood River	Madison County T5N, R9W sec 28	November 20-21, 1962	84	10	64-84	1	491	134,000	60	2,240	0.155
Southwestern Campus of IU, Edwardsville	Madison County T4N, R8W sec 20	December 13-17, 1960	95	10	75-95	4	308	131,000	84	1,560	0.020
Shell Oil Company	Madison County T5N, R9W sec 33	March 3-6, 1952	100	12	?	3	510	210,000	100	2,100	0.002
Mobil Oil Company	St. Clair County T2N, R10W sec 25	October 25-26, 1961	114	16	79-114	1	630	212,000	73	2,900	0.100
Monsanto Chemical Corporation	St. Clair County T2N, R10W sec 27	August 4-8, 1952	99	12	89-99	4	1,100	210,000	75	2,800	0.082

<sup>a)</sup> Schicht (1965)

Table 11. Summary of Water-Quality Analyses for USEPA Priority Pollutant and Non-Priority Pollutant Organic Compounds, Monsanto Company, W.G. Krummrich Plant, Sauget, Illinois (concentrations are in ug/L).

<u>Mean Values</u>					
Well No.	Volatile Organic Compounds	Acid Extractable Organic Compounds	Base/Neutral Extractable Organic Compounds	Pesticides/PCBs	Total Mean Concentration
<u>Geraghty &amp; Miller, Inc. Monitoring Wells</u>					
GM-1	32*	ND <sup>1)</sup>	3	ND	35
GM-2	64*	ND	10	ND	74
GM-3	39*	ND	3	ND	42
GM-4A	25*	ND	4	ND	29
GM-4B	9,300	62	900	ND	10,300
GM-4C	6,950	102	813	ND	7,860
GM-5	60*	ND	2	ND	62
GM-6A	177	ND	3	ND	180
GM-6B	2,220	2	124	ND	2,350
GM-7	37*	ND	5	ND	42
GM-8	44	ND	4	ND	48
GM-9A	1,400*	106	82	ND	1,590
GM-9B	1,248	3	41	0.006	1,292
GM-9C	160	8	63	0.002	231
GM-10A	40*	ND	5	ND	45
GM-10B	1,060	128	770	ND	1,960
GM-10C	68	ND	27	ND	95
GM-11	38*	ND	4	ND	42
GM-12A	2,410	104	357	ND	2,880
GM-12B	2,000	21	64	5	2,090
GM-12C	220	180	84	ND	484
GM-13	88,000	1,400 <sup>2)</sup>	4,760	53	94,000
GM-14	155,000	NA	NA	ND	155,000
GM-15	153	1	244	5	403

1) Not Detected.

2) Not Analyzed.

Table 11. (cont'd.)

Well No.	Volatile Organic Compounds	Acid Extractable Organic Compounds	Base/Neutral Extractable Organic Compounds	Pesticides/PCBs	Total Mean Concentration
<u>Geraghty &amp; Miller, Inc. Monitoring Wells</u>					
GM-16A	6	ND	3	ND	9
GM-16B	23	2	12	19	56
GM-17A <sup>3)</sup>	105,400	256	4	0.112	105,700
GM-17B	57,000	220	64	0.5	57,000
GM-17C	13,900	88	1,340	0.1	15,400
GM-18A	25	ND	3	0.122	28
GM-18B	270	3	4	0.149	277
GM-25A	12	ND	23	0.004	35
GM-25B	2	1	21	0.48	24
GM-27B	481	129	28	18	656
GM-27C	1,660	150	130	18	1,950
GM-28B	5,720	2,893	824	175	9,610
GM-28C	5,400	1,695	1,810	0.262	8,900
GM-29	6	12	14	0.129	32
GM-30	333	ND	105	ND	438
GM-31A	184	18,800	318	ND	19,300
GM-31B	52	0	15	ND	67
GM-31C	591	60	32	ND	683
GM-106	120	300	354	ND	774
<u>Landfill Monitoring Wells</u>					
B-24A	16,110	600,000	479,340	ND	1,100,000
B-25A	30,000	130,000	172,480	ND	330,000
B-25B	14,200	112,400	25,270	ND	151,900
B-27B	52,600	NA	NA	ND	52,600
B-28A	1,510	ND	ND	ND	1,510

<sup>3)</sup> September 1984 volatile organic analysis was omitted because the laboratory could not determine the quantitative values for benzene and chlorobenzene.



Table 11. (cont'd.)

Well No.	Volatile Organic Compounds	Acid Extractable Organic Compounds	Base/Neutral Extractable Organic Compounds	Pesticides/PCBs	Total Mean Concentration
<u>Landfill Monitoring Wells (cont'd.)</u>					
B-29A	2,200	1,389,000	1,550	ND	1,393,000
B-29B	22,000	329,000	7,900	ND	359,000
B-30B	7,150	NA	NA	ND	7,150
B-31B	ND	ND	53	ND	53
B-31C	224	2	41	0.015	267
B-101	16,000	52,800	94,300	ND	163,100
B-102	26	ND	4	ND	30
P-1	4	4	17	ND	25
P-2	849	182	16	ND	1,047
P-6	190	3	ND	ND	190
P-7	7,080	97,300	191,000	ND	295,000
P-8	1,970	126	107	ND	2,200
P-10	2,000	ND	8	0.562	2,000
P-11	991	ND	106	1	1,098
P-12	1,340	ND	144	34	1,520
P-13	33,000	3	144	ND	33,000
P-14	20,000	53	33	ND	20,000
<u>Dewatering Wells in the Plant Area</u>					
DW-1	112,400	225	531	ND	113,200
DW-4	14,120	1,940	441	0.534	16,470
DW-7	670	300	1,120	ND	2,100
DW-10	18,780	42	1,007	0.136	19,830
<u>Monitoring Wells in the Plant Area for Dewatering Projects</u>					
BK-3	3,670	13	300	0.016	4,000
DW-34	201,000	81	4	ND	201,000
<u>Dewatering Wells for the Treatment Plant Sewer Construction</u>					
DW-1-85	6,530	34	429	ND	6,960
DW-18	600	0.3	55	0.005	660
DW-23	6	ND	189	0.066	195
DW-24	6	ND	2	ND	8

Table 11. (cont'd.)

Well No.	Volatile Organic Compounds	Acid Extractable Organic Compounds	Base/Neutral Extractable Organic Compounds	Pesticides/PCBs	Total Mean Concentration
<u>Monitoring Wells for the Treatment Plant Dewatering Projects</u>					
DW-29	662	26	2	0.013	690
DW-30	172	4	47	ND	223
DW-33	9	4	4	0.02	17
<u>Offsite Wells</u>					
WB-6	178	21	750	ND	950
WB-7	80	ND	4	0.129	80

\* Priority Pollutants only

Table 12. Summary of Volatile Organic Compounds in Ground Water, W.G. Krumrich Plant, Monsanto Company, Sauget, IL. \*\*\*

Well Number:	GM-12A	GM-12A	GM-12A	GM-12A	GM-12A	GM-12A	GM-12A	GM-12A	GM-12A	GM-12A
Date:	11/83	11/83*	5/84	5/84*	11/84	11/84*	2/85	2/85*	5/85	5/85*
USEPA Priority Pollutant										
Volatile Organic Compounds										
concentrations are in ug/L										
acrolein	<1	<1	<1	<1	<100	<1000	<100	<100	<100	<100
acrylonitrile	<1	<1	<1	<1	<100	<1000	<100	<100	<100	<100
benzene	425	433	3,263	4,819	1,790	3,590	1,030	1,160	2,270.3	1,819.1
bis (chloromethyl) ether	<1	<1	<1	<1	<10	<100	<10	<10	<10	<10
bromoform	<1	<1	<1	<1	<10	<100	<4.7	<4.7	<4.7	<4.7
carbon tetrachloride	<1	<1	<1	<1	<10	<100	<2.8	<2.8	<2.8	<2.8
chlorobenzene	350	296	304	399	286	565	349.3	399.3	453.4	471.9
chlorodibromomethane	<1	<1	<1	<1	<10	<100	<3.1	<3.1	<3.1	<3.1
chloroethane	<1	<1	<1	<1	<10	<100	<10	<10	<10	<10
2-chloroethylvinyl ether	<1	<1	<1	<1	<10	<100	<10	<10	<10	<10
chloroform	18	21	<1	<1	<10	<100	<1.6	<1.6	<1.6	<1.6
dichlorobromomethane	<1	<1	<1	<1	<10	<100	<2.2	<2.2	<2.2	<2.2
dichlorodifluoromethane	<1	<1	<1	<1	<10	<100	<10	<10	<10	<10
1,1-dichloroethane	<1	<1	<1	<1	<10	<100	<4.7	<4.7	<4.7	<4.7
1,2-dichloroethane	<1	<1	<1	<1	<10	<100	<2.8	<2.8	<2.8	<2.8
1,1-dichloroethylene	<1	<1	<1	<1	<10	<100	<2.8	<2.8	<2.8	<2.8
1,2-dichloropropane	<1	<1	<1	<1	<10	<100	<6	<6	<6	<6
cis-1,3-dichloropropylene	<1	<1	<1	<1	<10	<100	<5	<5	<5	<5
trans-1,3-dichloropropylene	<1	<1	<1	<1	<10	<100	<10	<10	<10	<10
ethylbenzene	4	4	17	17	17	<100	20.2	22	13.9	14.6
methyl bromide	<1	<1	<1	<1	<10	<100	<10	<10	<10	<10
methyl chloride	<1	<1	<1	<1	<10	<100	<10	<10	<10	<10
methylene chloride	49	64	23	31	<10	<100	<2.8	<2.8	<2.8	<2.8
1,1,2,2-tetrachloroethane	<1	<1	<1	<1	<10	<100	<6.9	<6.9	<6.9	<6.9
tetrachloroethylene	<1	<1	<1	<1	<10	<100	<4.1	<4.1	<4.1	<4.1
toluene	4	4	17	22	26	<100	31.2	29	12.2	12.3
1,2-trans-dichloroethylene	<1	<1	<1	<1	<10	<100	<1.6	<1.6	<1.6	<1.6
1,1,1-trichloroethane	8	7	<1	<1	<10	<100	<3.8	<3.8	<3.8	<3.8
1,1,2-trichloroethane	<1	<1	<1	<1	<10	<100	<5	<5	<5	<5
trichloroethylene	<1	<1	<1	<1	<10	<100	<1.9	<1.9	<1.9	<1.9
trichlorofluoromethane	<1	<1	<1	<1	<10	<100	<10	<10	<10	<10
vinyl chloride	<1	<1	<1	<1	<10	<100	<10	<10	<10	<10
Sub Total 1	858	829	3624	5288	2119	4155	1430.7	1610.3	2749.8	2317.9
Miscellaneous										
Volatile Organic Compounds										
methyl-iso-butyl ketone	NA	NA	NA	NA	<10	<100	<10	<10	<10	<10
methyl isobutyl ketone	NA	NA	NA	NA	<10	<100	<10	<10	<10	<10
m-xylene	NA	NA	NA	NA	17	<100	17.1	18.5	11	12.6
o-xylene/p-xylene	NA	NA	NA	NA	49	<100	55.3	59.5	43	49.7
Sub Total 2	NA	NA	NA	NA	66	0	72.4	78	54	62.3
Total VOC's Analyzed	858	829	3624	5288	2185	4155	1503.1	1688.3	2803.8	2380.2

Table 12. Summary of Volatile Organic Compounds in Ground Water, W.G. Krumrich Plant, Monsanto Company, Sauget, Il. \*\*\*

Well Number: 6M-12A 6M-12A 6M-12A 6M-12A  
 Date: 11/85 11/85\* 2/86 2/86\*  
 USEPA Priority Pollutant  
 Volatile Organic Compounds  
 concentrations are in ug/L

acrolein	<1,000	<1,000	<100	<100
acrylonitrile	<1,000	<1,000	<100	<100
benzene	1,730	1,540	1,170	1,160
bis (chloroethyl) ether	<100	<100	<10	<10
bromoform	<47	<47	<4.7	<4.7
carbon tetrachloride	<28	<28	<2.8	<2.8
chlorobenzene	428	403	499	394
chlorodibromomethane	<31	<31	<3.1	<3.1
chloroethane	<100	<100	<10	<10
2-chloroethylvinyl ether	<100	<100	<10	<10
chloroform	<16	<16	<1.6	<1.6
dichlorobromomethane	<22	<22	<2.2	<2.2
dichlorodifluoromethane	<100	<100	<10	<10
1,1-dichloroethane	<47	<47	<4.7	<4.7
1,2-dichloroethane	<28	<28	<2.8	<2.8
1,1-dichloroethylene	<28	<28	<2.8	<2.8
1,2-dichloropropane	<60	<60	<6	<6
cis-1,3-dichloropropylene	<50	<50	<5	<5
trans-1,3-dichloropropylene	<100	<100	<10	<10
ethylbenzene	<72	<72	11.3	7.9
methyl bromide	<100	<100	<10	<10
methyl chloride	<100	<100	<10	<10
methylene chloride	599	443	<2.8	6.5
1,1,2,2-tetrachloroethane	<69	<69	<6.9	<6.9
tetrachloroethylene	<41	<41	<4.1	<4.1
toluene	<60	<60	<6	<6
1,2-trans-dichloroethylene	<16	<16	<1.6	<1.6
1,1,1-trichloroethane	<38	<38	<3.8	<3.8
1,1,2-trichloroethane	<50	<50	<5	<5
trichloroethylene	<19	<19	<1.9	<1.9
trichlorofluoromethane	<100	<100	<10	<10
vinyl chloride	<100	<100	<10	<10

Sub Total 1 2757 2386 1680.3 1568.4

Miscellaneous  
 Volatile Organic Compounds

methyl-iso-butyl ketone	<100	<100	<10	<10
methyl isoamyl ketone	<100	<100	<10	<10
m-xylene	<100	<100	<10	<10
o-xylene/p-xylene	<100	<100	20	16.9

Sub Total 2 0 0 20 16.9

Total VOC's Analyzed 2757 2386 1700.3 1585.3

NA - Not analyzed.

\* - Replicate Analyses

\*\* - Prior to analysis, this sample was held by Envirodyne Engineers, Inc. longer than the maximum allowable USEPA holding time.

\*\*\* - Envirodyne Engineers, Inc. (St. Louis, MO.) provided the laboratory services for the sampling rounds conducted between November, 1983 and September, 1984, with the exception of the January through May, 1984 sampling rounds conducted in the W.G. Krumrich Landfill. These wells are designated as the "B" series (i.e. B-22A) and the "P" series (i.e. P-7) and D'Appolonia (currently IT Corporation), Pittsburgh, Pa., provided the chemical results. ETC (Edison, NJ) performed the analyses for the November 1984 through February 1986 sampling programs.

Table 13. Mean Concentrations of Volatile Organic Compounds in Field, Trip and Laboratory Blanks

	<u>Field Blanks (8)*</u>			<u>Trip Blanks (9)*</u>			<u>Laboratory Blanks (17)*</u>		
	<u>Frequency of Occurrence above Detection Limits</u>	<u>Range (ug/L)</u>	<u>Mean** (ug/L)</u>	<u>Frequency of Occurrence above Detection Limits</u>	<u>Range (ug/L)</u>	<u>Mean** (ug/L)</u>	<u>Frequency of Occurrence above Detection Limits</u>	<u>Range (ug/L)</u>	<u>Mean** (ug/L)</u>
Benzene	1	ND-28	4	3	ND-31	7	8	ND-34	7
Chlorobenzene	3	ND-53	10	1	ND-2	0.2	4	ND-53	3
Methylene Chloride	4	ND-39	10	6	ND-130	31	15	ND-50	21
Total Volatile Organics	6	ND-94	24	7	ND-158	43	16	ND-87	34

\* Number of samples

\*\* For calculations, ND values were regarded as 0.

ND - Not Detected.

Table 14. Analysis of Precision and Error  
Among Replicates from Well GM-12A

Date	Replicate Concentrations (ug/L)	Mean (ug/L)	Precision <sup>1)</sup> (Standard Deviation)	Measurements in both Conc. Range <sup>2)</sup> and Within Expected Precision	Relative Error (%)
<u>CHLOROBENZENE</u>					
11/83	350, 296	323	51.6	yes	8
5/84	304, 399	352	56.1	yes	14
11/84	286, 565	426	68 <sup>a)</sup>	no	33
2/85	349.3, 399.3	374	59.8	yes	7
5/85	453.4, 471.9	463	73.9	yes	2
11/85	428, 403	416	66.4	yes	3
2/86	499, 394	447	71.4	yes	12
Average					11
<u>XYLENES</u>					
11/83	NA	---	---	---	--
5/84	NA	---	---	---	--
11/84	49, <100	---	---	---	--
2/85	55.3, 59.5	57.4	3.0*	---	4
5/85	43, 49.7	46.4	4.7*	---	7
11/85	<100, <100	---	---	---	--
2/86	20, 16.9	18.4	2.2*	---	8
Average					6
<u>TOLUENE</u>					
11/83	4, 4	4	0.11	no	0
5/84	17, 22	20	2.2 <sup>a)</sup>	no	15
11/84	26, <100	---	---	---	--
2/85	31.2, 29	30.1	3.8	yes	4
5/85	12.2, 12.3	12.3	1.12	no	0.8
11/85	<60, <60	---	---	---	--
2/86	<6, <6	---	---	---	--
Average					5

Table 14 (Continued).

Date	Replicate Concentrations (ug/L)	Mean (ug/L)	Precision <sup>1)</sup> (Standard Deviation)	Measurements in both Conc. Range <sup>2)</sup> and Within Expected Precision	Relative Error (%)
<u>BENZENE</u>					
11/83	425, 433	429	5.66	yes	0.9
5/84	3263, 4819	4041	1100	no	19
11/84	1790, 3590	2690	1273	no	33
2/85	1030, 1160	1095	92	no	6
5/85	2270.3, 1819.1	2044.7	268	no	11
11/85	1730, 1540	1635	134	no	6
2/86	1170, 1160	1165	7.1	no	0.4

Average

11

ETHYLBENZENE

11/83	4, 4	4	1.56	no	0
5/84	17, 17	17	3.38	yes	0
11/84	17, <100	---	---	---	--
2/85	20.2, 22	21.1	3.9	yes	4
5/85	13.9, 14.6	14.2	3.0	no	2
11/85	<72, <72	---	---	---	--
2/86	11.3, 7.9	9.6	2.3	no	18

Average

5

1) Expected Precision for Distilled Water Data (USEPA, 1984)

Chlorobenzene	0.16 $\bar{x}$ - 0.09
Xylenes	none
Toluene	0.15 $\bar{x}$ - 0.71
Benzene	0.26 $\bar{x}$ - 1.74
Ethylbenzene	0.14 $\bar{x}$ + 1.00

2) Method Ranges of Concentration (ug/L)

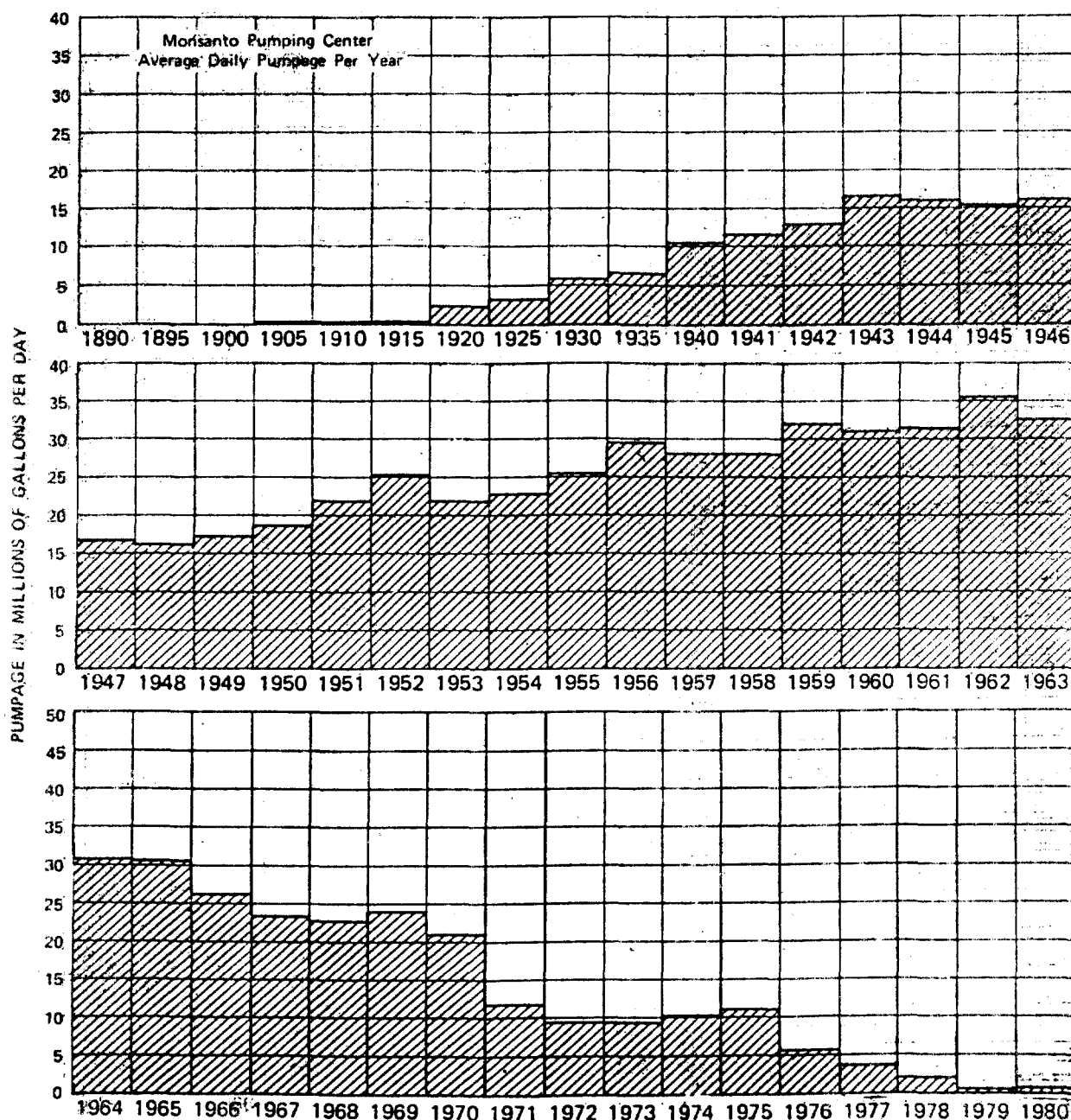
13.5 - 600
none
13.5 - 600
10.8 - 480
15 - 690

a) Does not fall within the expected precision range.

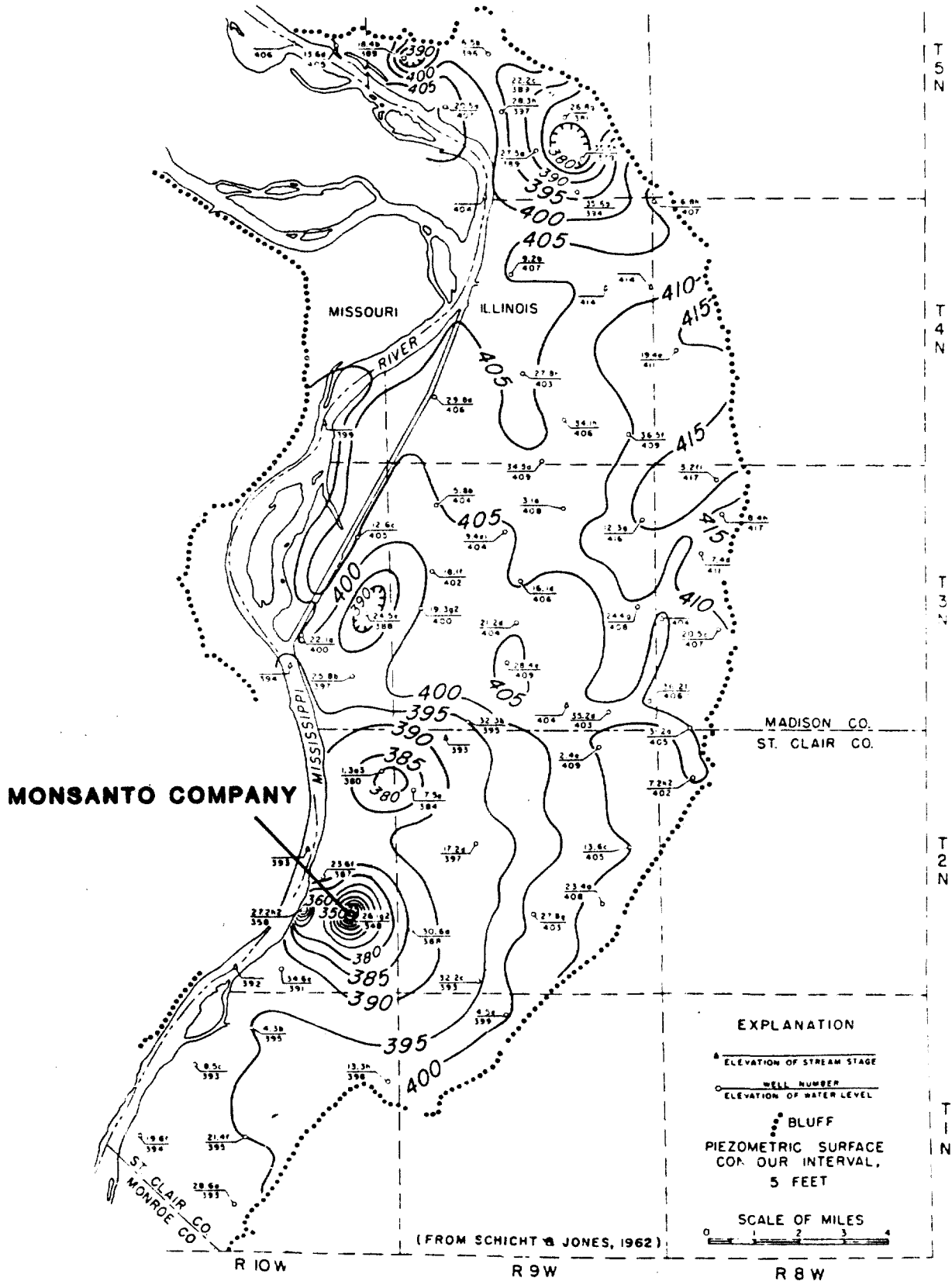
\*There are no precision criteria for xylenes.



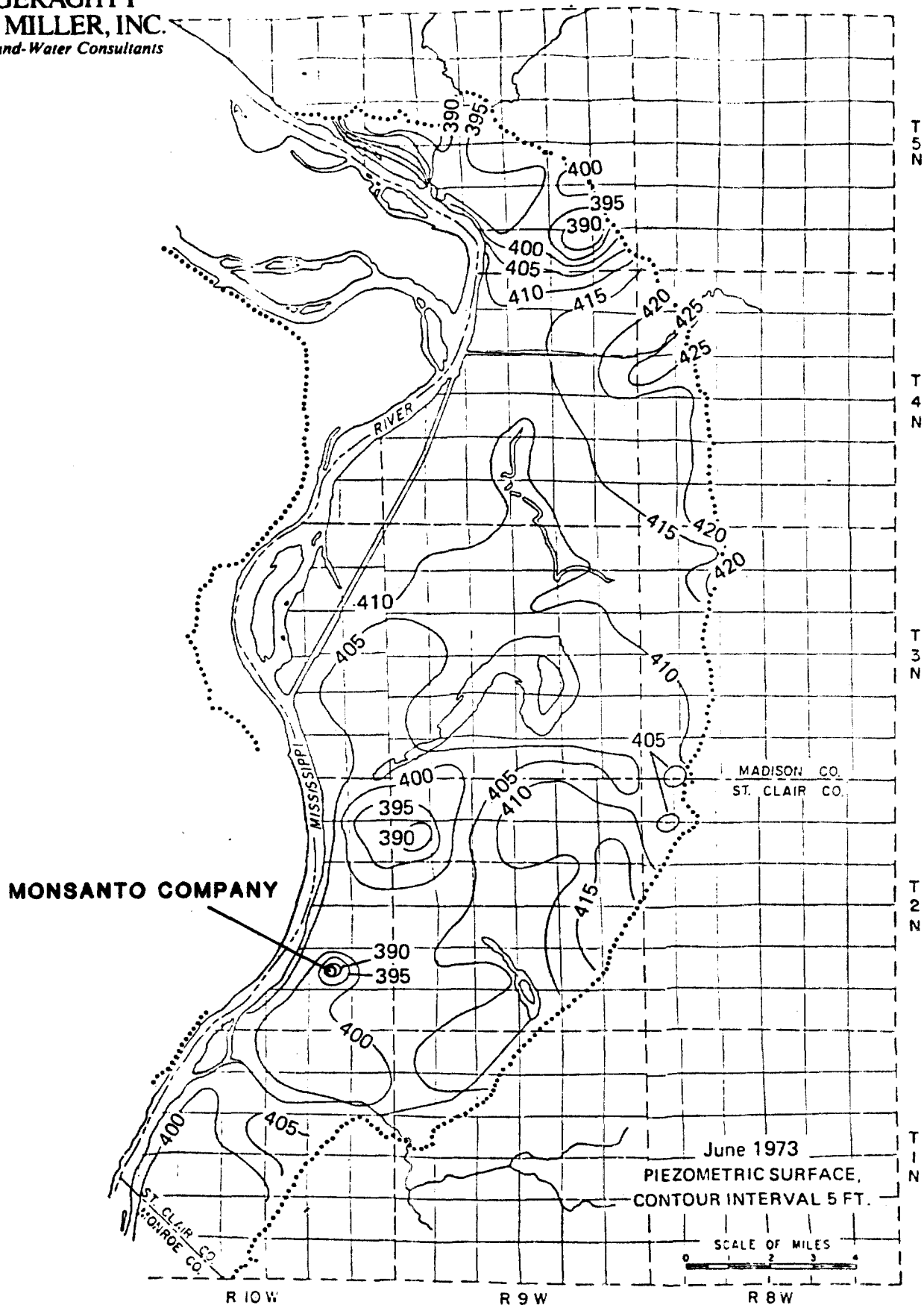
## FIGURES



**ESTIMATED PUMPAGE IN THE EAST ST. LOUIS-SAUGET-CAHOKIA AREA, 1890-1980  
MONSANTO COMPANY, SAUGET, ILLINOIS**

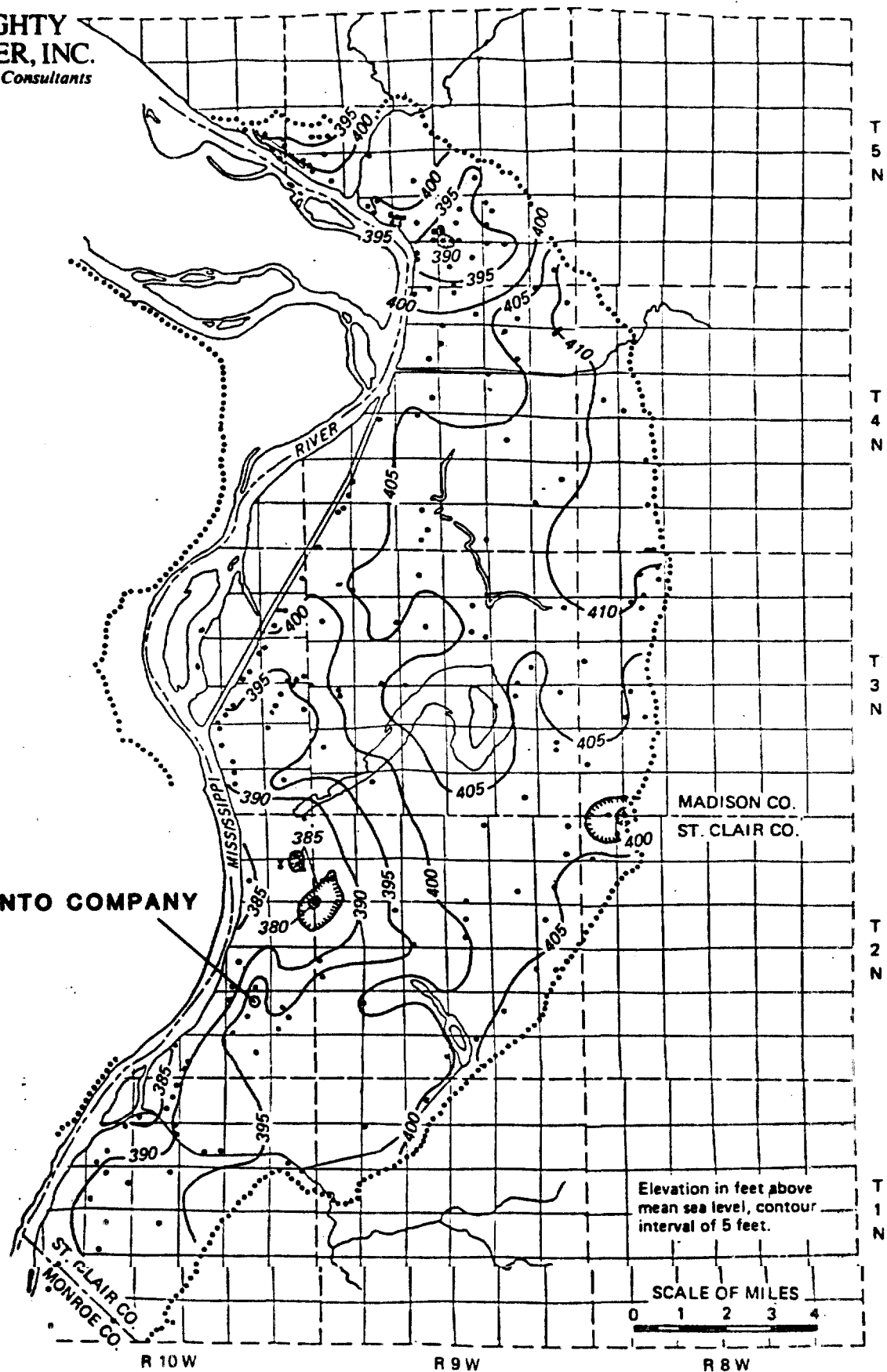


**APPROXIMATE ELEVATION OF THE POTENTIOMETRIC SURFACE, NOVEMBER 1961  
MONSANTO COMPANY, SAUGET, ILLINOIS**



**APPROXIMATE ELEVATION OF THE POTENTIOMETRIC SURFACE, JUNE 1973  
MONSANTO COMPANY, SAUGET, ILLINOIS**

**MONSANTO COMPANY**



**APPROXIMATE ELEVATION OF THE POTENTIOMETRIC SURFACE, NOVEMBER 1980  
MONSANTO COMPANY, SAUGET, ILLINOIS**

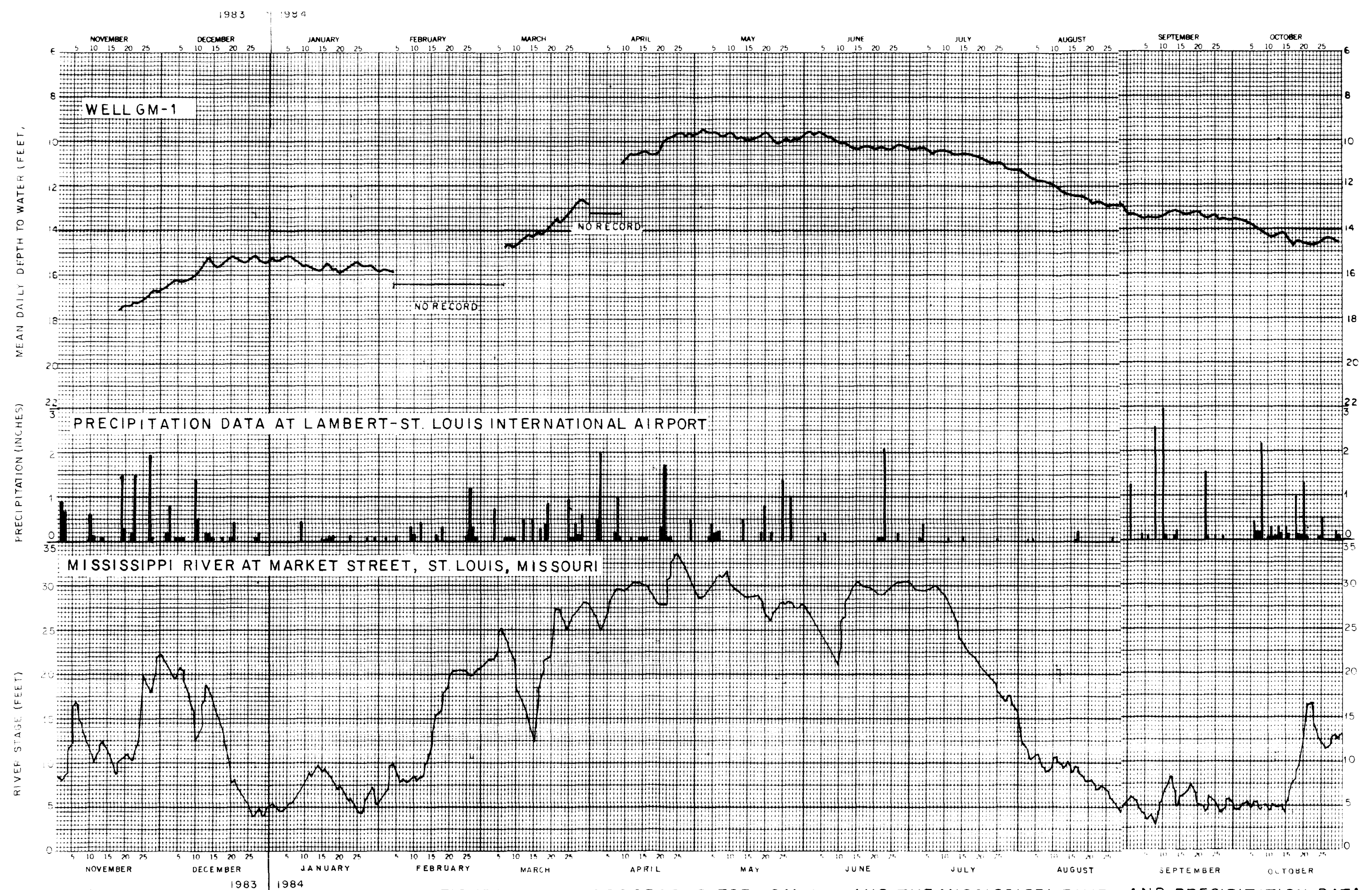
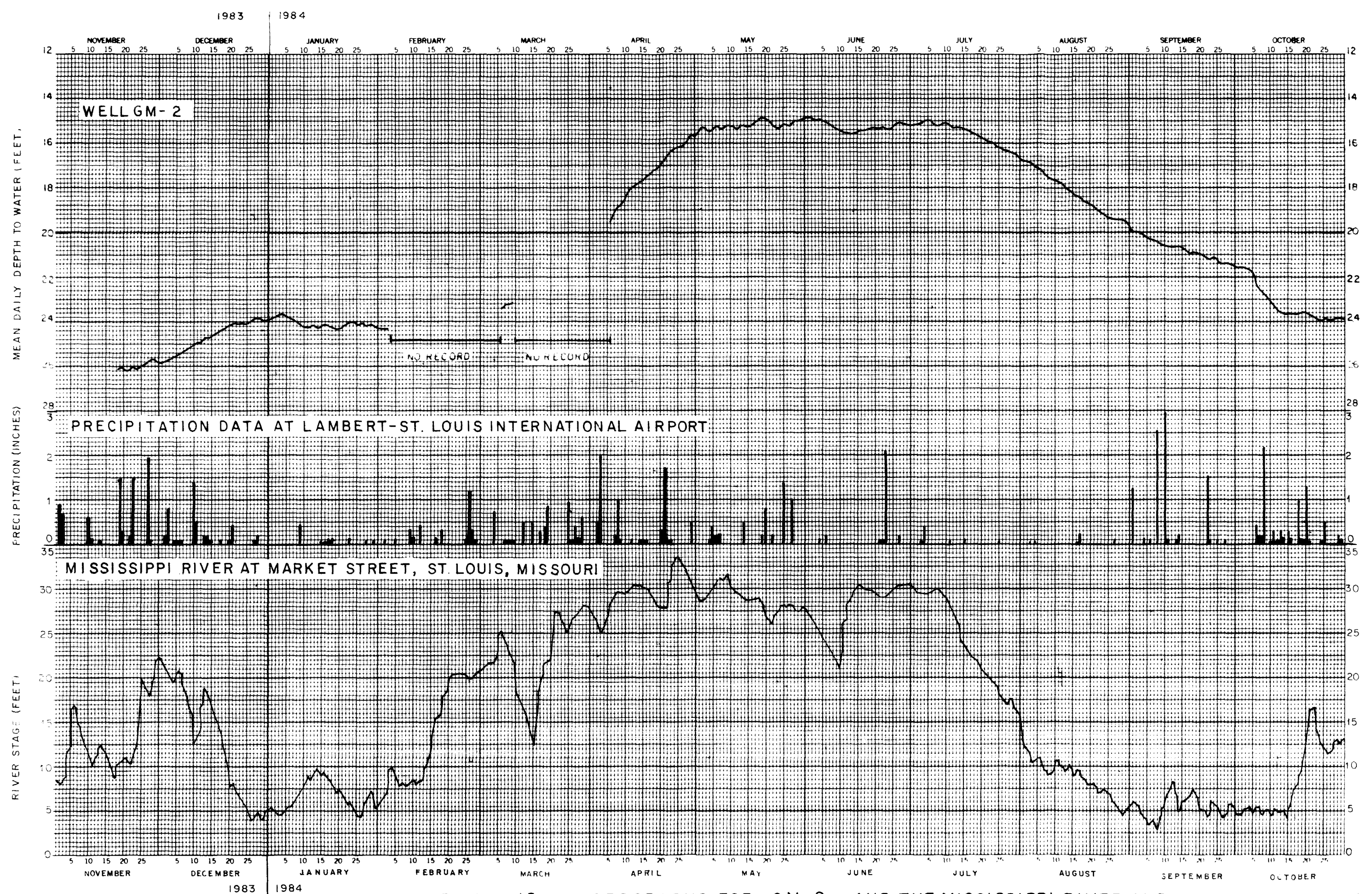


FIGURE 15 - HYDROGRAPHS FOR GM-1 AND THE MISSISSIPPI RIVER AND PRECIPITATION DATA  
 MONSANTO COMPANY W.G. KRUMMRICH PLANT SAUGET, ILLINOIS





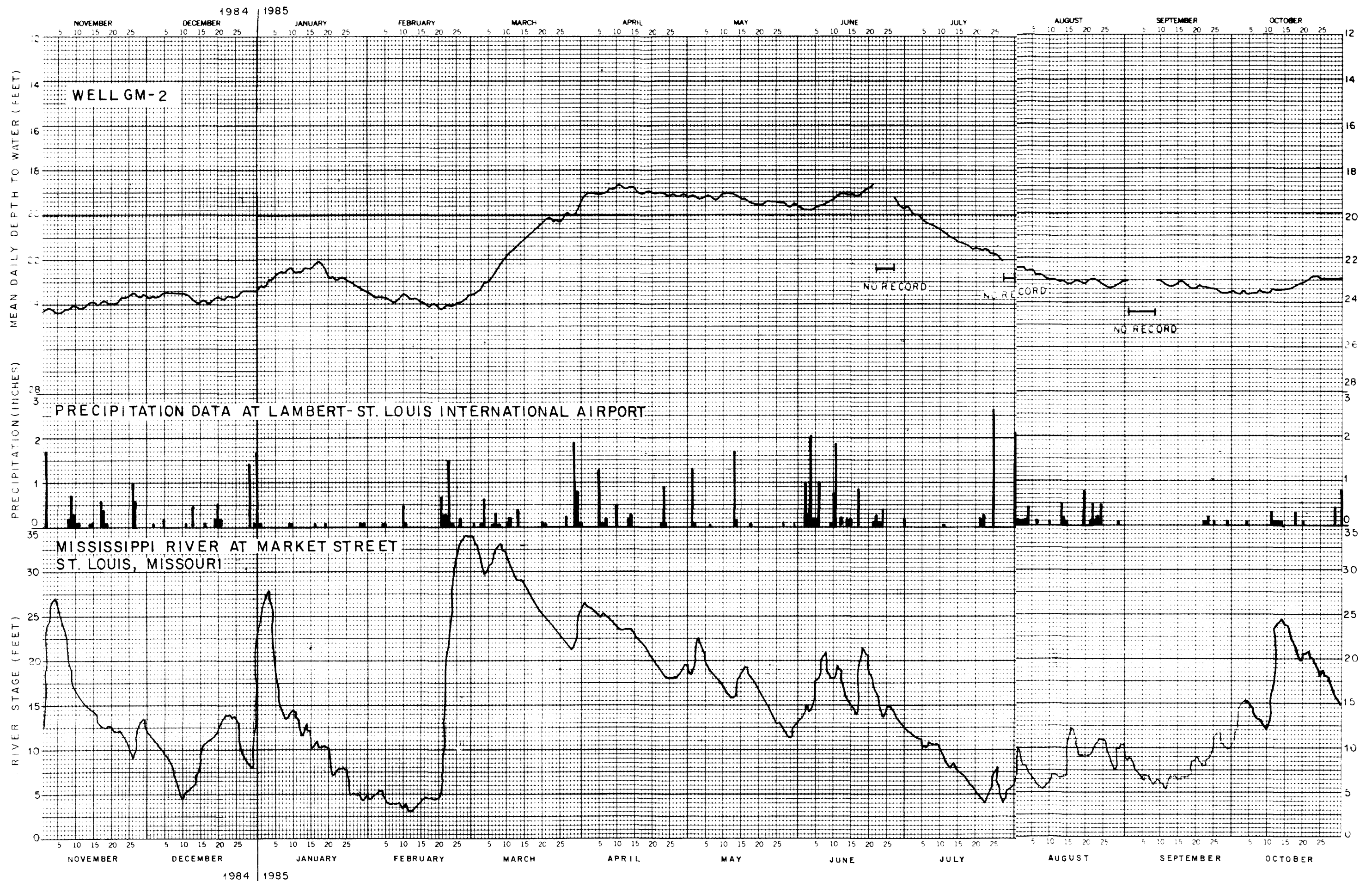


FIGURE 16 - (Continued)



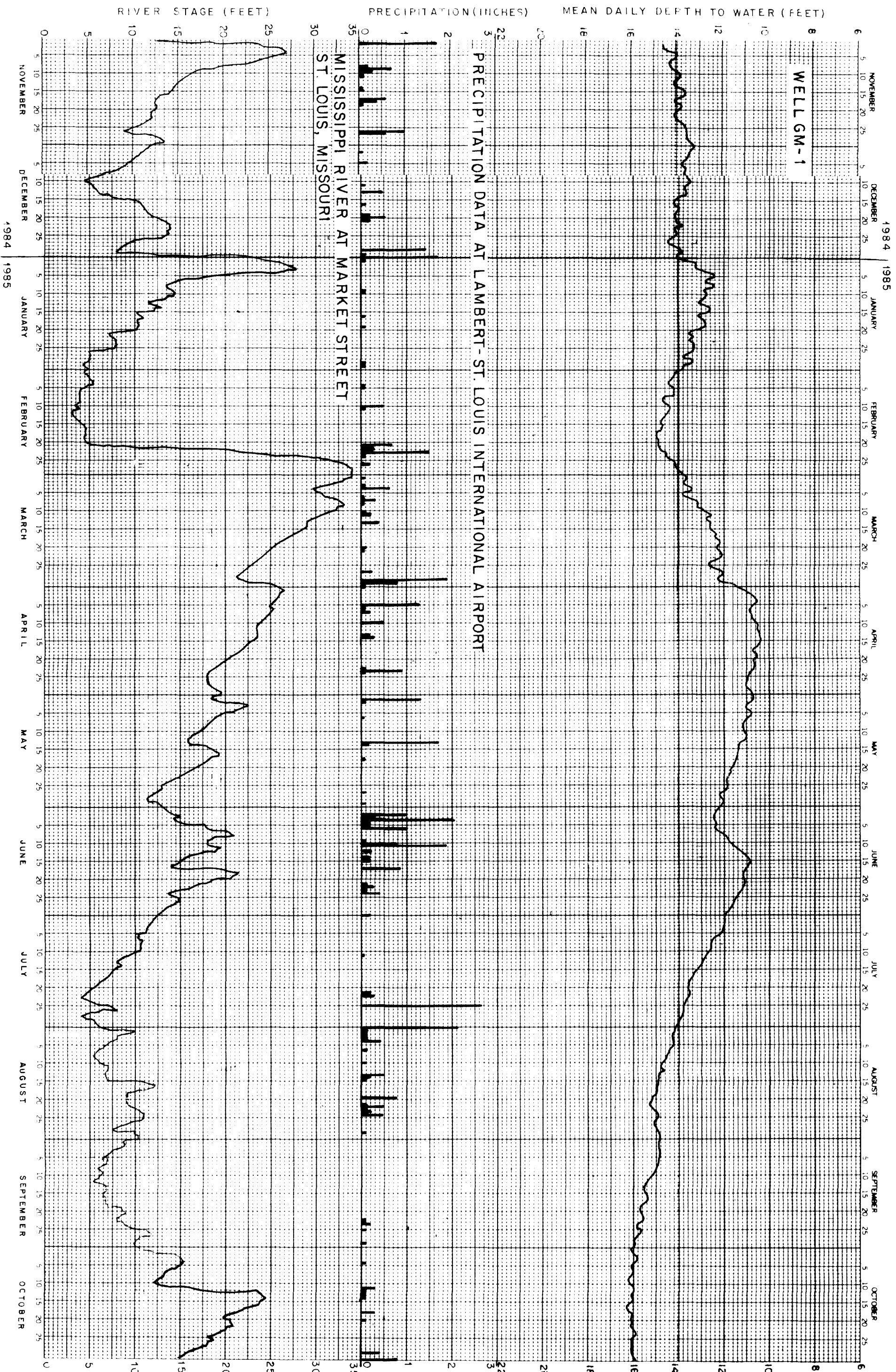


FIGURE 15 - (Continued)

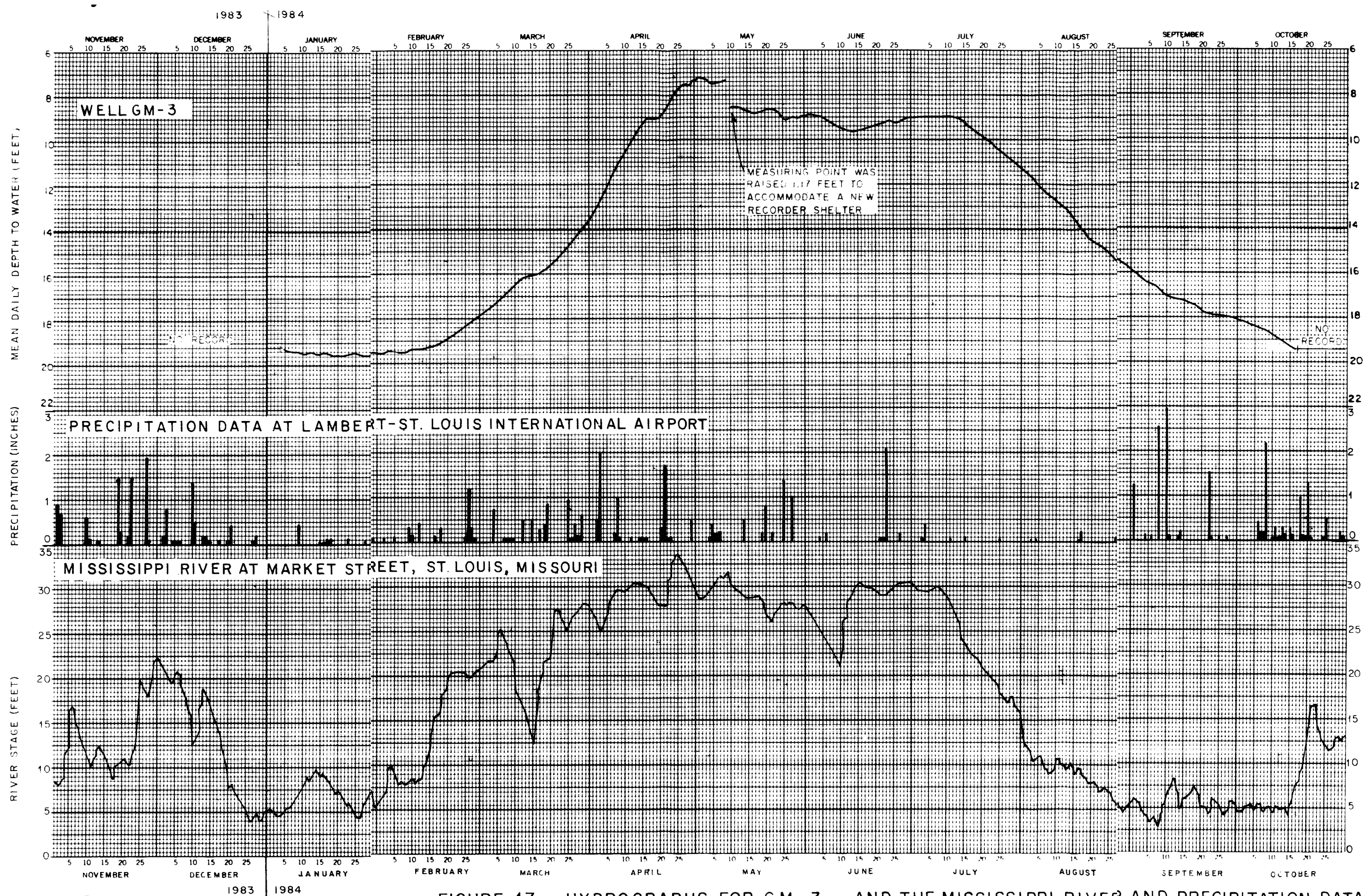


FIGURE 17 - HYDROGRAPHS FOR GM-3 AND THE MISSISSIPPI RIVER AND PRECIPITATION DATA  
MONSANTO COMPANY W.G. KRUMMRICH PLANT SAUGET, ILLINOIS



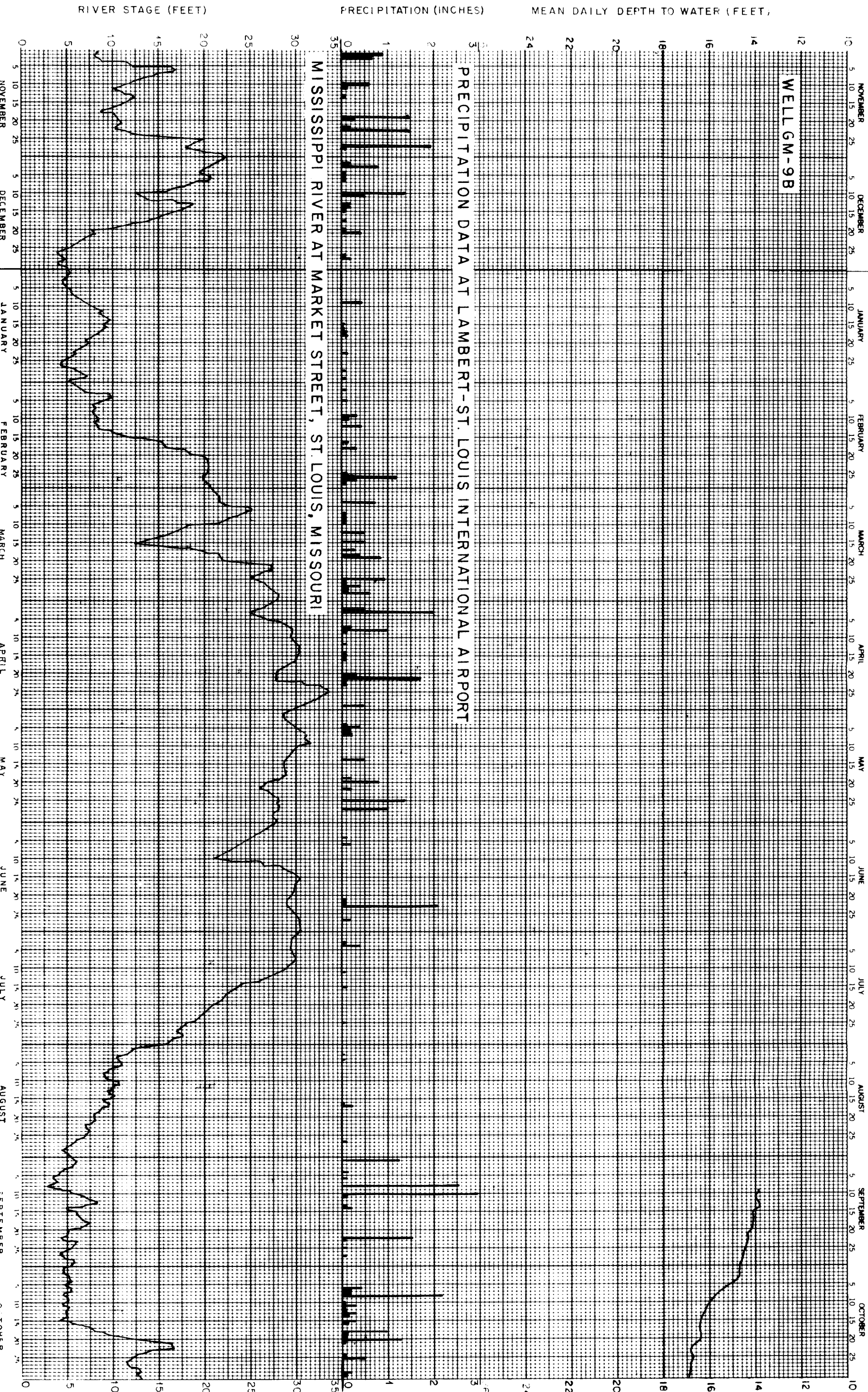


FIGURE 18 – HYDROGRAPHS FOR GM-9B AND THE MISSISSIPPI RIVER AND PRECIPITATION DATA



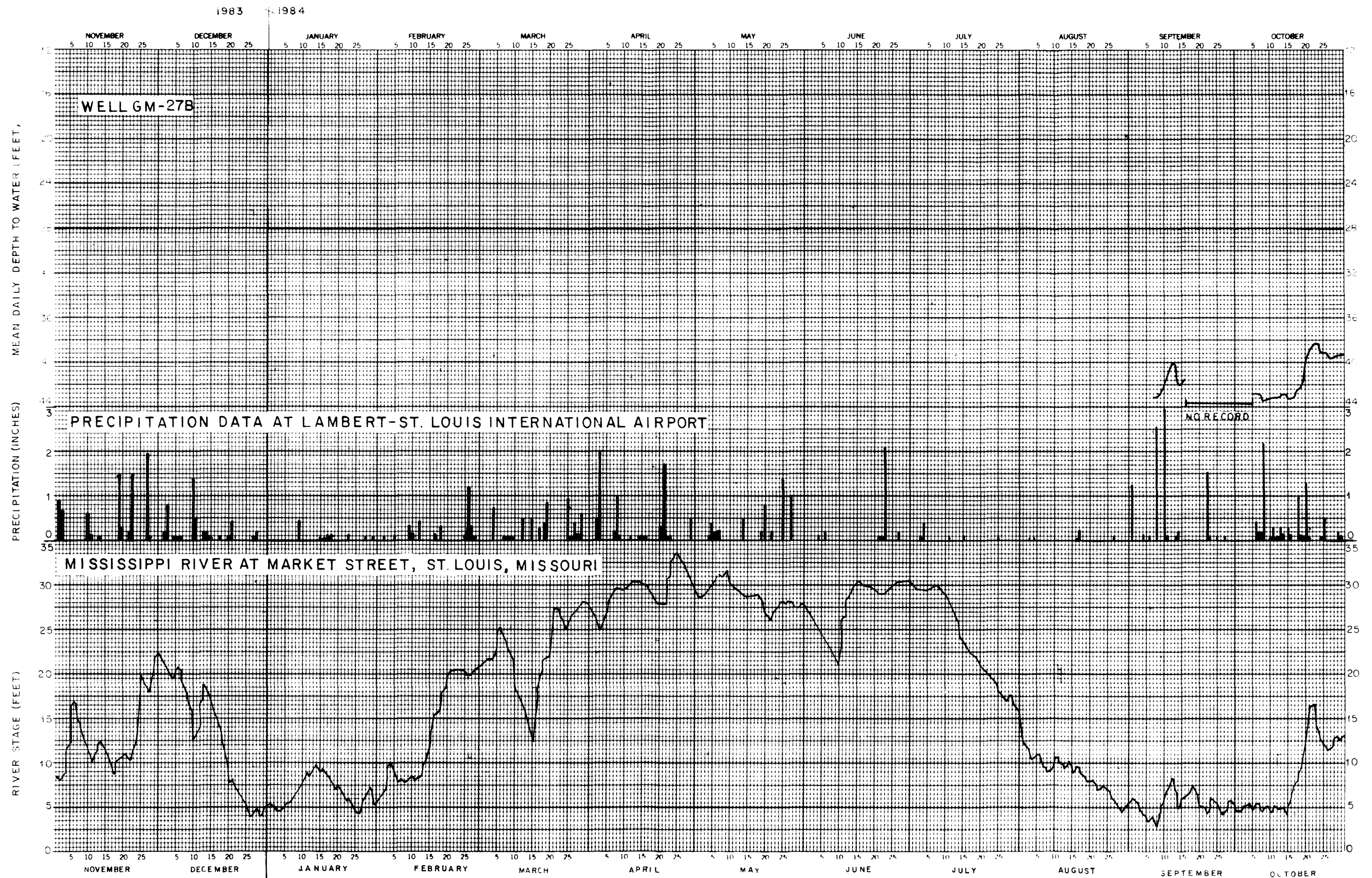
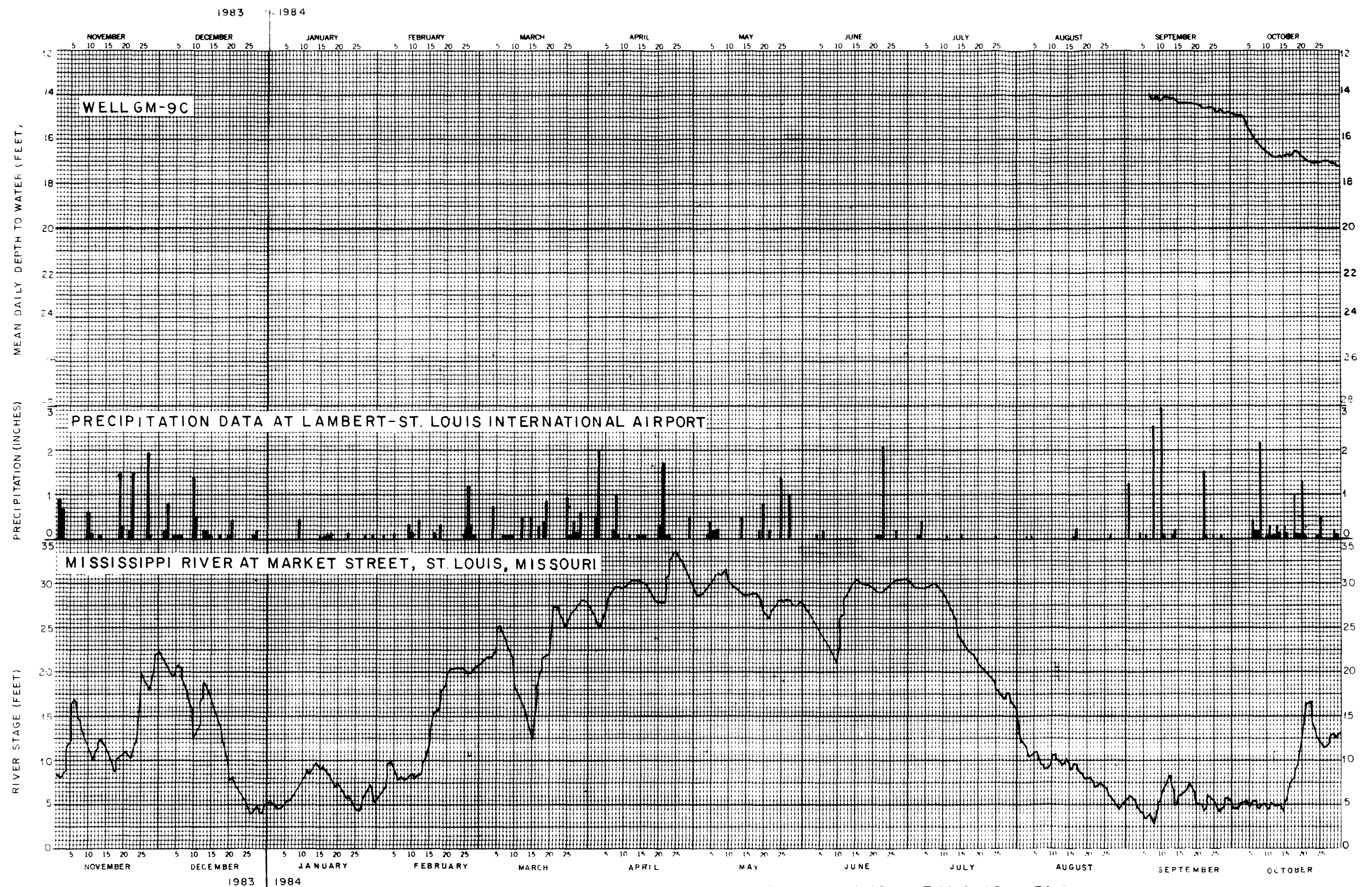


FIGURE 19 - HYDROGRAPHS FOR GM-27B AND THE MISSISSIPPI RIVER AND PRECIPITATION DATA  
MONSANTO COMPANY W.G. KRUMMRICH PLANT SAUGET, ILLINOIS







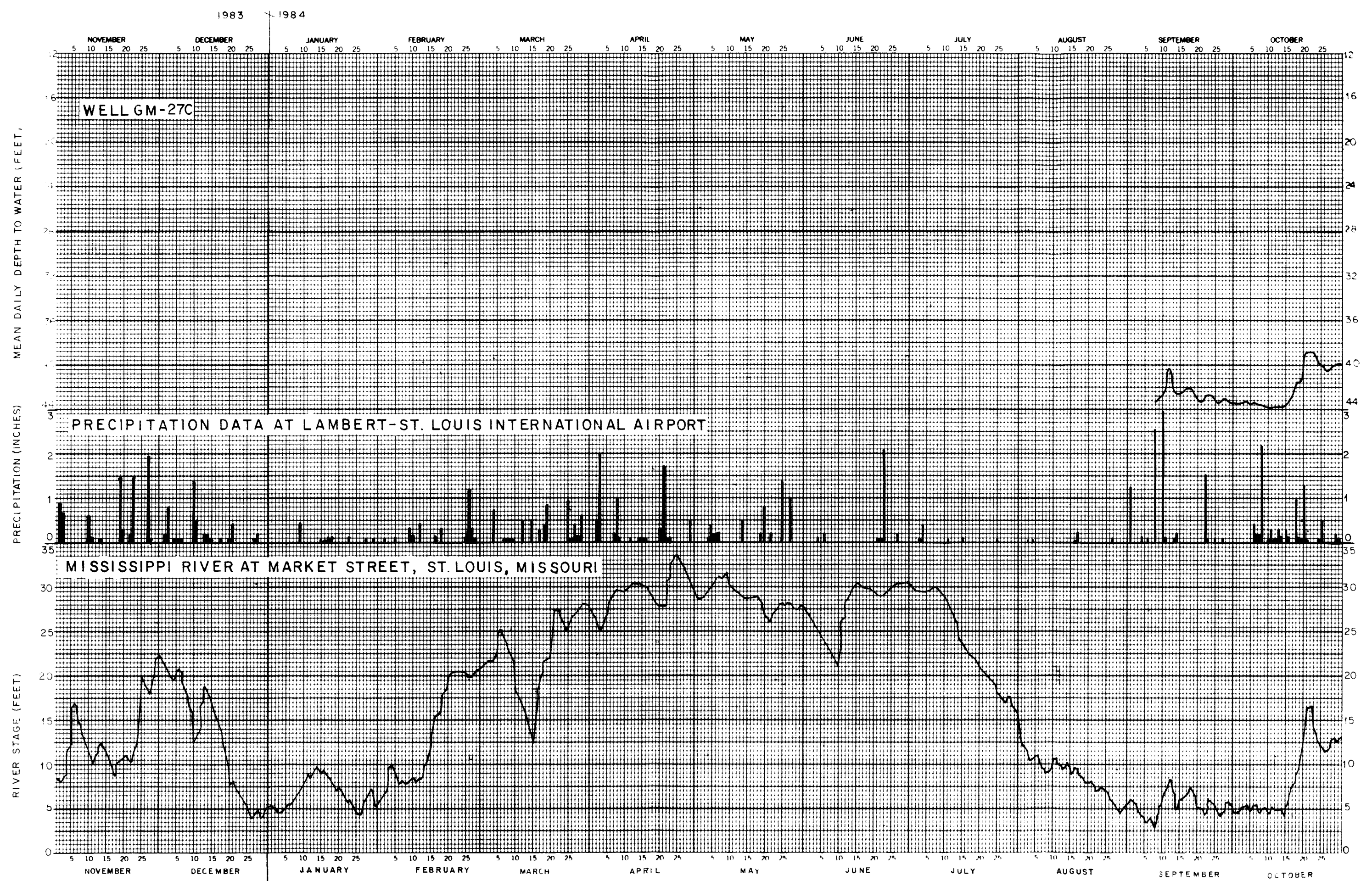


FIGURE 21 - HYDROGRAPHS FOR GM-27C AND THE MISSISSIPPI RIVER AND PRECIPITATION DATA  
MONSANTO COMPANY W.G. KRUMMRICH PLANT SAUGET, ILLINOIS

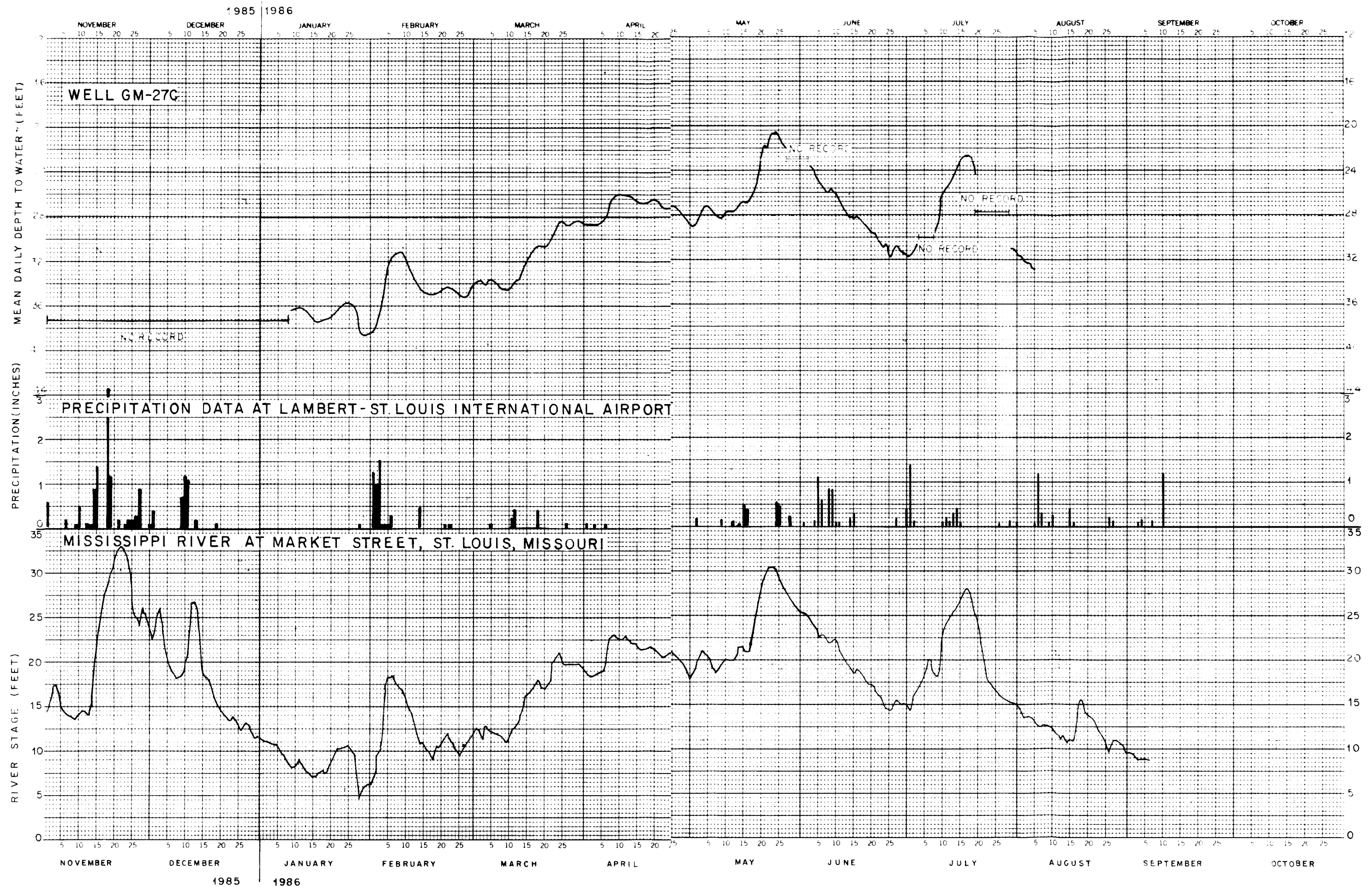


FIGURE 21 - (Continued)